

2-10-2021 1:30 PM

# Visualizing Anishinaabe Ceramics: A Collaborative Approach to Digital Archaeology

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A thesis submitted in partial fulfillment of the requirements for the Master of Arts degree in Anthropology

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## Abstract

This thesis explores how collaboration can enrich and inform a digital-archaeological project and the process of braiding interests of archaeologists and Indigenous community partners. Research was conducted in partnership with the staff from the Ojibwe Cultural Foundation (OCF) on Manitoulin Island. We focused on the production of a digital model and 3D print of Anishinaabe ceramics from the Providence Bay archaeological site. The OCF wanted the material culture from Providence Bay accessible to community members as the ceramics themselves were too fragile for display or teaching without risking further damage. A 3D print of a Providence Bay vessel was produced using archaeological illustration methods in a 3D modelling program (Blender), creating a model of a pot informed by previous archaeology. This partnership also resulted in the development of a novel methodology (the OCF Aahnkesjihgeh Method). Our partnership highlights the ways in which collaboration can incorporate multiple perspectives in digital-archaeological research.

Keywords: Digital archaeology, community-based archaeology, collaboration, 3D Scanning, 3D modelling, Open access

## Summary for Lay Audience

This thesis explores how collaboration can benefit a digital-archaeological project and the process of braiding the interests of archaeologists and Indigenous community partners. Research was conducted with the staff from the Ojibwe Cultural Foundation (OCF) on Manitoulin Island. We focused on producing a digital model and 3D print of Anishinaabe ceramics from the Providence Bay archaeological site. The OCF wanted the material culture from Providence Bay accessible to community members as the ceramics are too fragile for display or teaching without risking further damage. A 3D print of a Providence Bay vessel was produced using common archaeological illustrations methods in a 3D modelling program (Blender), creating a model of a pot based on the archaeology. This partnership also resulted in the development of a new methodology (the OCF Aahnkesjihgeh Method). Our partnership highlights how collaboration can incorporate multiple perspectives in digital-archaeological research.

## Acknowledgements

In finishing this project there are so many people to whom I am deeply grateful.

First, and most importantly, I want to thank everyone at the OCF. Thank you so much to Anong Beam. Your perspective and insight made it possible for me to see the archaeology differently. All of the time, energy and effort was so appreciated and can be seen in our results. Next, thank you to Sophie Corbiere and Naomi Recollet. Your patience and assistance, especially in the latter portions of this project, will not be forgotten. Another thank you to Leona Nawegahbow for your assistance with spelling Aahnkesjihgeh (pattern making or puzzle solving), as this helped Anong and I capture what this method was to us. Next, thank you to all the members of the OCF over the years that have fed me. All of those meals and coffees were delicious and made me feel so welcome. Thank you to everyone at the OCF that took the time to teach me things. Thank you, Darlene Bebonang, for teaching me beadwork. I still haven't gotten my brick stitch down pat... but I will keep trying. Thank you, Dr. Alan Corbiere, your knowledge and input was always valued, especially everything you were able to teach me about the history of Providence Bay. Finally, I want to acknowledge the Elders of OCF that have since passed, specifically Lewis Debassige whom I spoke with on a few occasions before the research intensive phase of this project was underway and helped to shape my understanding of Providence Bay. You had so much to share and I am so grateful for the time I had with you. You are deeply missed.

Next, I want to thank my supervisor, Dr Neal Ferris. You have been supervising me and providing insight on the chaos I bring to things for roughly six years now in different capacities and I appreciate all of your time and effort. Thank you for believing in me and seeing that I had something different and unique to offer archaeology. Your guidance and encouragement have often help put me back on track when I am completely at a loss for what my next steps should be and at times you have shown me that I am capable of more than I thought possible.

Thank you to everyone in the Anthropology department at Western. I have always felt supported and valued in our department and want to acknowledge all of the amazing faculty members in the department that put so much time into making sure we are ok, especially throughout the pandemic. I also want to acknowledge the amazing administrative staff members in our department, Laura Cousins, Ed Eastaugh, Laura Flemming and Christine Wall. You all do a lot to support the graduate students in this department. Finally, thank you to my cohort and all the amazing friends I have made in the department. You are all amazing and these friendships mean so much to me.

I also owe a thank you to Carolyn Podruchny from York University, the lead organizer of the Manitoulin Island Summer Historic Institute in partnership with the OCF. These conferences were such an excellent opportunity to gather with others on Manitoulin Island and share my research with everyone. Carolyn also provided me with so much valuable assistance throughout the process and I am so appreciative of the time you took to help me navigate academia.

Next, a huge thank you to everyone at the Museum of Ontario Archaeology. You have all taught me so much and given me the space, time and freedom to learn all of the skills that were applied in this thesis. Thank you to Dr Rhonda Bathurst and Dr Heather Hatch for all of their support at the museum and finally, thank you to R. Colin Creamer who always had time for my 3D modelling questions.

I owe so many thanks to my family members that have been so supportive throughout my degree. You always show so much interest in my work and provide so much encouragement. Thank you to my mother, my sister, my uncle and last, but certainly not least, my grandfather who has supported my education from the very beginning.

Lastly, thank you to A. B. Thank you for the space, patience, kindness and encouragement you have provided me. I have been very lost at times and you have been a grounding force that has helped me find my way.

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## **Chapter 1: Introduction**

### **1.1: Overview**

This thesis explores the ways in which collaboration can enrich, inform, and alter the development of a digital archaeological project and the process of braiding research interests in this context. The research for this thesis was conducted with the Ojibwe Cultural Foundation (OCF) and focused specifically on 3D modelling of ceramics from the Late Woodland Period Providence Bay site on Manitoulin Island. The initial goal of this research was to take highly fragmented ceramics from the OCF's collections and create digital models that would estimate their unbroken form by blending ceramic reconstruction and illustration methodologies with 3D modelling techniques. What we were able to produce in the end was a digitally constructed pot, informed by ceramic sherd analyses and a collaborative discussion about the craft and heritage of Indigenous potting. This process allowed me to test the model I was able to produce by integrating a limited number of scanned ceramic sherds from the archaeological assemblage into the modelled pot to create a 3D printed version of the composite. This process was a detailed method that could be replicated by individuals with limited 3D modelling experience.

The OCF, and particularly their Executive Director at the time, Anong Beam, contributed to the process at various stages and provided valuable insight into ceramic manufacture as she has a lifetime of experience working with and making pottery herself. The models created in this research were planned to be used in educational workshops the OCF was planning to run to teach participants about traditional Anishinaabe ceramic manufacture. This tactile engagement can allow participants to

interact with these vessels in a way that would not have been possible otherwise, as most ceramics in the collection are highly fragmentary. A 3D print would make it possible to present the ceramics to patrons of the OCF in a palatable and engaging way that we hoped would assist learners in gaining a better understanding of traditional vessel form. In joining our efforts and contributing our unique perspectives, this process allowed us to create a product that met the diverse goals we both envisioned for this research.

One of the main goals of this research was to ensure that the process used to model a ceramic vessel from Providence Bay artifacts was replicable for the OCF. All stages of modelling were documented for the centre, and a manual of the methodology can be found in Appendix 1. In appendix 1 I provide the “paradata” (see Carter 2017) behind the decision-making that went into this project and digital build, which will allow the OCF to follow, or diverge, from the path we took through this project in the future. The method has been named “The OCF Aahnkesjihgeh Method.” In trying to make the process transparent and potentially replicable, an aim of the project was to provide the OCF with one possible manner of accessing the Indigenous heritage of pottery making beyond the constraints of the fragmentary archaeological record going forward.

All modelling undertaken for this thesis was focused on one vessel, listed in site documentation as “Algoma Lipnotch Vessel 97,” which was represented by an estimated 30% of its original body size in the collections. Indeed, most of the ceramics from Providence Bay were highly fragmentary. As such, the OCF and I recognized that this archaeological absence of data would require collaborative extrapolation and interpretation, which shaped each of the three phases of the project that went into

informing the final model. First, the Executive Director of the OCF, Anong Beam, and I began by consulting one another about the project. We then moved on to creating preliminary models and experimenting with the vessel form digitally. The final phase was the development of a polished and printable model. Collaboration and communication were imperative at all stages of this project to ensure that both the interests of the OCF and myself were prioritized together.

## **1.2: History of the Collections**

In the decade before this project, the United Chiefs and Council of Mnidoo Mnising (UCCMM) had negotiated with the Province of Ontario over the long-term storage and care of Indigenous archaeological collections from central northern Ontario. The province was closing their storage unit in Sudbury, and the UCCMM wanted to have all archaeological collections from Manitoulin Island returned; to be held at the OCF's new archival space. The MTCS agreed to return these collections to the community, as well as all Ministry collections between Manitoulin Island and James Bay. These provincial collections, primarily held in Sudbury, were subsequently brought to the OCF. Shortly afterwards, when Anong began working for the OCF, one of her first jobs was to organize a gallery exhibit that would display some of these collections, notably from the Providence Bay archaeological site.

Anong indicated that looking at this collection was eye-opening, as the site report listed portions of 123 distinct ceramic vessels that had been unearthed during excavations at the site in the 1980s. Anong had grown up making pottery with her family and had been told throughout her life that this practice was not an Anishinaabe tradition. However, the material from Providence Bay appeared to contradict that narrative. Even

though archaeologists had studied these ceramics, information about them and this potting tradition had not made it back to the community. Though familiar to archaeologists, the archaeological record had not become a part of local Manitoulin Island heritage.

Anong's career as an artist includes learning to work with ceramics as a child as both of her parents were artists as well and did work with ceramics themselves. Her father, Carl Beam, was fascinated by methods of ceramic manufacture used throughout the Americas and studied them extensively. The family moved to the American Southwest in 1980, where Carl, Anong and her mother Anne learned more about this craft (Hill, Beam, and McMaster 2010:42). Throughout their travels, Carl photographed everything the family did and practiced. The albums of photographs the family took during this period are now curated by the National Gallery of Canada. The techniques they studied on their travels led to the development of the family's unique method of pottery manufacture. This is the context that informed Anong as she initially examined and learned about the practice of pottery making at Providence Bay, which facilitated our initial collaborative partnership on this project.

### **1.3: Digital Archaeology**

As investigations into digital imaging and archaeology have proceeded over the last two decades, researchers have explored how this technology can be applied to archaeological research (Barber, Maxwell, and Hemi 2014; Galeazziup and Di Giuseppantonio Franco 2017; Maxwell 2017; Reilly 1990). Many of these approaches involve the production of 3D models of artifacts or virtual reality experiences that can immerse viewers in a space, and it is this range of applications of the technology that I



am most interested in (Barone et al. 2018; Betts et al. 2011; Dawson, Levy, and Lyons 2011; Haburaj et al. 2019). These technologies are usually praised for their ability to make it possible to interact with artifact collections and archaeological contexts in novel ways, while making the archaeological record more accessible (Galeazziup and Di Giuseppantonio Franco 2017; Means 2015; Younan and Treadaway 2015). Over the years, the cost of using this technology in archaeology has become less prohibitive, so that now it is relatively easy to develop and implement digitally-based archaeological research projects (Haukaas and Hodgetts 2016; Pierdicca et al. 2016).

Proponents of Digital archaeology argue that the incorporation of this technology into our work not only illustrates archaeology in novel ways, but also allows the archaeologist to interpret the archaeological record differently. For example, Katz (2017) created a digital library of 3D models of Mayan musical instruments, which he argues can serve as a replacement source of information for scholars looking to study these artifacts by providing them with a consolidated, online, and accessible space. He feels that access to this body of material will allow scholars to embrace novel research from this assembled collection. While Katz indicates this research could be expanded in the future to include the voices and opinions of community members, it is currently a digital library intended for scholars to access and interpret the archaeological record freed from the barriers of travel and the fragility of the artifacts.

Likewise, Schofield et al's (2018) efforts to create a virtual reality exhibition of a 9th Century Viking encampment examined how new forms of archaeological interpretation can be made possible through the use of virtual archaeology. This project was a deep exploration of the embodied experience of standing in one of these

encampments, providing patrons at the Yorkshire Museum with a more interactive experience. The major benefit that the team found in working in VR was the lack of real-world physical building restrictions, which was not an issue working within VR space. The team was able to create four distinct scenes that patrons could view from a fixed standing position. These scenes also incorporated 20 artifacts from the archaeological site itself, connecting the virtual space with the material heritage of that place. These examples of 3D modelling and virtual archaeology are dimensions of an emerging Digital Archaeology that point towards new ways of both doing and thinking about archaeology through digital applications.

#### **1.4 Digital Community Archaeology**

Supporters of Digital Archaeology have also promoted these practices as a way to enable a broader access to the archaeological heritage by the public and communities (e.g., Bollwerk 2015; Means 2015). With this increased access comes more opportunities to interact with and know the past, which has been praised as a means to also make Indigenous heritage accessible to Indigenous Descendant communities (Colwell-Chanthaphonh et al. 2010). The inclusive and far-reaching philosophies of Digital Archaeology dovetail perfectly with the aims of an Indigenous Archaeology that also seeks to increase the representation of, as well as the participation and access by, Indigenous Descendant communities within archaeological discourse and practice (Nicholas 2016; Silliman 2010).

While many archaeologists today agree that archaeological practice was previously exclusionary, and the future of the practice needs to be multivocal, there is a considerable amount of academic hand wringing about what the best practices are for

doing this work (La Salle and Hutchings 2016; Martindale et al. 2016). What I feel is vital going forward is the need for our archaeological practice to be inclusive of Indigenous Descendant communities. Digital Archaeology and Indigenous Archaeology together provide us with opportunities to increase the diversity of voices across these discourses and is a vital step away from the exclusionary practices of the past (Townsend et al. 2020). The colonial legacies of archaeological practice and the exclusion of Indigenous peoples' access to interpret or even know about their material heritage has been acknowledged and grappled with in archaeology for decades now (Dei 2000:113; Thomas 2008:xi). Archaeology as a discipline is moving towards recognizing the importance of practice being, in part or whole, in the service of Indigenous and other Descendant communities, and needs to be inclusive and open to all perspectives and ways of knowing. The issues regarding these legacies, to expanding archaeological practice so that it is inclusive of Indigenous ways of knowing and controlling their heritage, and developing the capacity to braid archaeological research with Indigenous ways of knowing, must work through the gamut of past and present systemic exclusion, the racism inherent in archaeology and the academy more generally, and knowing the past beyond Western knowledge systems (Atalay 2006; Cutler 1970; Dei 2000:113; O'Farrell 1979). To overcome these legacies, most archaeologists today, including myself, acknowledge that archaeology must work to leave this archaeological past behind.

Today in archaeology there are many scholars and communities committed to collaboration and even the blending of methods to enrich understandings of the past, both in the context of archaeologists and Indigenous communities working together

(e.g., Cipolla, Quinn, and Levy 2019; Gonzalez and Edwards 2020; Lelièvre et al. 2020; Martindale and Lyons 2014), and across non-Indigenous Descendant communities (Barton and Markert 2012; Riley and Harvey 2005). To exclude specific ways of knowing the past from archaeological research excludes that diversity of perspectives and voices from contributing to the discourse. As a result, we lose out on ways of knowing that could deepen our understanding of the past and that heritage (Dei 2000:120).

Digital archaeology lends itself well to furthering a collaborative form of archaeological knowledge making while advancing this shift in archaeological practice, and more specifically allowing for an Indigenous, digital community-based archaeology to grow (Haukaas and Hodgetts 2016). In a community-based digital archaeological project, researchers and community members co-create the digital content and ensure that the final product meets the aims and goals of the community (Haukaas and Hodgetts 2016; Magnani, Guttorm, and Magnani 2018). Such a dynamic collaboration allows for the braiding of research interests (Victor et al. 2016), and ensures all partners contribute and shape the project.

Because digital archaeology gives researchers the ability to make changes to the product we are creating, multiple iterations can be informed by feedback from all the collaborators contributing to that project (Carter 2017:124). The non-destructive nature of this work also presents significant advantages when looking at artifacts as there is little risk of damaging material culture. Digital community-based archaeology allows all research partners to come together to co-create their projects.

For example, in the case of visual interpretations, the collaborative process is made tangible and visible. One such project was the partnership between the Arviat Hunters and Trappers Organization (HTO) and Peter Dawson of the University of Calgary (Dawson et al 2018). That partnership was focused on creating a virtual guided tour of two important heritage sites in the Arviat Inuit community: Arvia'juaqand and Qiqiktaarjuk. In this project, local cultural historians were responsible for determining and articulating the best possible vantage points from which important cultural features could be seen, while digital archaeologists made their vision a virtual reality (Dawson et al. 2018:255). This project was viewed as a success by community partners as it allowed the community access to the sites without the need for travel, and it made it possible for students to visit the site from schools. I hope that the research undertaken for this MA also demonstrates the real potential a collaborative digital archaeology has to serve more than just archaeological knowledge.

## **1.5 Conclusion**

Following initial talks about this project with OCF staff, I was very interested in applying my 3D scanning and modelling skills to a project that would require extrapolation of archaeological data. I had spent a considerable amount of time creating 3D scans and models for archival purposes. However, I had spent far less time extrapolating that artifact data. The OCF's goal to share the material heritage of Providence Bay aligned well with my goal of applying digital archaeological skills to a project that was meaningful beyond archaeology. It was this common ground that paved the way for the work that followed.

In Chapter 2, I will discuss the history of the Providence Bay site and digital and community-based archaeology. This chapter provides the necessary background needed to understand how this MA came to be, as well as the research context that informed it. Chapter 3 will explore the collaboration that we engaged in throughout the course of this research. In Chapter 4 I review the technical processes that shaped this research, including the methods I employed to generate data from fragmentary ceramics, modelling and 3D scanning methodologies, and 3D printing. I will also review the different iterations of the digital model as it took shape, and the process and feedback from the OCF that informed each stage of the project. This chapter also provides a detailed description of the ways in which the modelling process altered the initial assumptions I had made on the shape of the vessel. Finally, Chapter 5 reviews what we achieved, as well as points to areas of future research.

## **Chapter 2: Background Research**

### **2.1: Site Background**

The Providence Bay site is mostly a Late Woodland period archaeological site located on the south coast of Manitoulin Island (see figure 2.1). Conway (1987) reported three components present on the site during his excavations in the 1980s: a mid-fifteenth through sixteenth-century component, a significant early seventeenth-century component, and a mid-nineteenth-century component. Most of the material from these excavations is related to the seventeenth-century component. The material culture from this period reflects extensive interaction with surrounding communities, both Indigenous and European (see also Fox 1990).

Long-distance exchange between Indigenous peoples and between Europeans and Indigenous communities across Lake Huron and southern Ontario in the seventeenth-century has been well studied (e.g., Fitzgerald 1990; Kenyon and Kenyon 1983). Likewise, Indigenous exchange of natural resources such as lithics and Lake Superior-based copper are found in places far from where they were harvested (Fox 2009). Some scholars have suggested that this broad exchange network is also implied by the diversity of the ceramic styles that are found on sites like Providence Bay (Mason 1981:14).

Excavations at the Providence Bay site occurred at two separate periods over the last 80 years. The first recorded excavations were led by Dr. Emerson Greenman from the University of Michigan in 1938. Greenman led a field school and conducted extensive research at nearby Killarney Bay on the north shore of Lake Huron between 1939-1953. During that time, he also spent one season at Providence Bay (Greenman

1924-1972, 1966). His excavation included opening a 30x50 foot trench on the site, though the materials recovered are not documented in his site notes. Fieldwork at Providence Bay resumed in the 1980s when Thor Conway of the then Ontario Ministry of Citizenship and Culture conducted a salvage excavation on the portion of the site eroding into the adjacent Mindemoya River (see figure 2.2) (Conway 1987). During the seasons he was there, he opened 11 units of various sizes across the site, the vast majority clustered along the bank of the river. This excavation recovered a large collection of materials, including an extensive ceramic assemblage interpreted to date to the early seventeenth-century. The materials from these Ministry-sponsored excavations are now under the care of the OCF.

Archaeological findings from Conway's work indicate that Providence Bay was roughly 4750 square meters in size, large enough for some researchers to suggest the site represents a former village (Milner 1998:425). Whether the full extent of the site encapsulates a single contiguous settlement or not would require further fieldwork. Regardless, this site would have been an extremely busy and diverse place where people resided or visited regularly, and included multiple areas for meal preparation, dwelling, fish and food preservation, and ritual activities (Smith and Prevec 2000:89). Conway interpreted the presence of multiple longhouse structures from the limited post mould patterns he recorded in units, and a possible palisade wall that surrounded this residential space (Conway 1988:3; Smith and Prevec 2000).

The presence of different, seasonally available faunal remains suggest occupation of the site was year-round. The faunal record indicates the residents of Providence Bay were highly skilled fishers due to the large volume of fish bones in the



collection. They were consuming a variety of fish in the summer, suckers in the spring, and whitefish in the fall (Smith and Prevec 2000:89). Throughout the winter, there is evidence that the residents were consuming cervids and medium-sized mammals such as beaver. The archaeological record, in effect, reflects the history of this place where people were born, lived, died, fished, celebrated and foraged.

## **2.2: Previous Understandings of Ceramics on Manitoulin Island**

Pottery is a highly versatile technology that has assisted those that have made and used it across the globe and dating back millennia (Hayden 1998; Rice 2015). The properties of clay plasticity before firing, and clay durability after being fired to a high temperature, makes it a highly versatile material and ubiquitous for assisting with essential tasks such as safe food storage and cooking. Pottery is often associated with populations that live sedentary or semi-sedentary lives in regions that have seasonal variation or that practice agriculture (Angourakis et al. 2015:357). It has been theorized that the adoption of pottery for storage was a slow process that in some regions around the world intensified along with the intensification of agriculture (Kuijt 2009:641). In the Northeast and Great Lakes region, however, ceramics appear long before regional communities intensified or even adopted agricultural practices in any notable way (e.g., Albert et al. 2018).

Ceramics found in an archaeological context survive relatively well, primarily as broken sherds. Most ceramics found on sites would have been made locally or within a limited region and shaped into vessels by hand without the aid of a potter's wheel. Most vessels documented from at least the last fifteen hundred years in the Great Lakes also typically feature incised or stamped decoration on the outer portion of the rim, which, for

some periods, also extend down the neck section of the pot (e.g., Ellis and Ferris 1990; Mason 1981). The styles and methods of manufacture practiced vary depending on the time and place vessels were made, and by the distinct communities of artisans who practiced their craft informed by local traditions and regional innovation (Milnar 2001). Archaeological ceramic traditions in time and place have often been pointed to as representing distinct cultural groups in the past, as well as reflecting broader pan-regional styles and pottery making innovations (e.g., Mason 1981; Wright 1972).

At Providence Bay, Conway documented more than 20 distinct decorative ceramic styles, associated with a range of ceramic traditions, across the 123 vessels he identified from his excavations (Conway 1988). Some archaeologists associate the high number of styles present at this site with pot trading (e.g., Garrad 1999; Mason 1981). However, it is more likely that the interaction of people created an environment whereby designs and potting practice innovations were broadly spread by artisans engaging with examples of ceramics from those other traditions and ceramic innovations in their own practice (e.g., Mazrim 2011).

Conway argued that the Providence Bay assemblage was representative of a vast social system of contact and exchange between artisans from a number of different areas. Certainly, ceramics of different styles present on Providence Bay are thought to be consistent with Late Woodland period ceramic traditions found widely across the Great Lakes region (Fox 1990).

Among the many distinct ceramic styles Conway reported at Providence Bay, he detailed vessels that, to him, appeared to be reminiscent of “Oneota ware, Michigan ware, Peninsular Woodland ware and Dumaw Creek ware” (Conway 1987:53). For

Conway, “Oneota ware” included vessels that had shell temper, thin walls and shared common styles of decoration reflective of archaeological traditions located to the west around Lake Michigan and beyond (Painter and O’Gorman 2019). “Peninsular” wares included a range of ceramic styles documented from northern Michigan and the Straits of Mackinaw, while “Dumaw Creek” included ceramic styles from western Michigan, and “Michigan” wares more generically supposedly referred to sixteenth- and seventeenth-century ceramic styles known elsewhere from southeastern Michigan (Fitting 1965). In general, these various wares reflect numerous stylistic elements commonly seen in this region and time period, and generally feature globular to round bodies, cord wrapping and or marking, mild neck tapering, and punctates, with the most common decorative feature being a notched rim (Fitting 1975:167-88). Conway also noted vessel fragments that appeared to reflect influences from Southern Ontario, notably vessels labelled “Ontario Horizontal.” These vessels feature short collars and incised oblique or cross-hatching patterns on the collar, and mostly plain bodies (Ramsden 1990). Notably, in the seventeenth-century component, there are instances of Huron-Wyandot-style pottery present, likely reflecting the close interaction between these communities (Fox 1990; Garrad 1999). The Odawa were documented to have wintered at Huron-Wyandot settlements, and because of this close relationship, the exchange of materials and ideas would have been possible (Fox 1990; Garrad 1999; Smith and Prevec 2000).

Conway also identified a distinct ceramic tradition at Providence Bay, which he referred to as “Algoma Ware” (Conway 1987:49, 1988:112). Algoma ware is described as a local style that has “a scalloped lip” and several other design features such as cord marking, mildly tapering collars, punctates, and stamping. Conway states that there are

four subtypes of Algoma ware: Corded, Collared, Stamped and Lip Notched (Conway 1988:119-121). While descriptions of pots that appear to be a part of the local manufacturing tradition are useful, Conway's description of Algoma ware appears slightly inconsistent in application across the vessel assemblage present in the archaeological collection. For example, not all vessels listed as "Algoma ware" actually feature a scalloped rim, and the vessel used for this MA research project, listed in the site report as "Algoma Lipnotch Vessel 97", does not exhibit a scalloped rim.

Nonetheless, the vessels Conway grouped under this ware type do appear to have a number of traits that suggest they were locally made, such as having a sandy temper. As a result, Conway's designation might be useful for identifying vessels that may have been manufactured at Providence Bay. Indeed, the most impactful aspect of Conway's work is his recognition that the residents of Providence Bay were both using and manufacturing ceramics of various styles indicative of the influence and interaction they had with those around them. This diversity of ceramics reflects a well-documented history and archaeology of Anishinaabe interaction with surrounding communities as they moved throughout the Lake Huron region.

Most notably, Excavation Unit 3 was found to have a cache of enough clay to manufacture a vessel, stored as clay balls (Conway 1988:20). This cache of clay would indicate that local artisans had plans to make new ceramics in the future at the site and thus represents direct archaeological evidence of the Anishinaabe pottery-making tradition carried out at this locale. Likewise, this excavation unit also yielded a fired clay disk alongside this stored clay. The clay disk is described as "unmarked with a smooth side and rounded edges" (Conway 1988:22), and Conway interprets its function as "a

castellation applique that was lost and fired,” though it was originally identified in the site maps as a “gaming disk.”

However, Anong offered the suggestion that the fired object might have been a ceramic test tile. Test tiles have been used by potters to determine if their clay fabric preparation or firing technique would be effective in reducing vessel loss when firing. Test tiling and test firing are common practices among modern potters and are an effective way for artisans to ensure that their clay will behave in predictable ways once fired (Leach, Dehnert, and Flood 2013; Rice 2015:288; Turner 2004). When creating a test tile, a small amount of clay is flattened into a disk or rectangle, and then this tile is fired. In the case of a more thorough testing, a miniature vessel can sometimes be constructed and fired. If the test tile survives the process, the potter can infer that it is safe to fire their vessels in the same manner. The presence of the object, if this is in fact a test tile, in Unit 3 at Providence Bay would suggest that artisans at Providence Bay were testing the properties of the clay vessel fabrics they were forming and firing on site. More generally, the identification of this object and a cache of clay balls all confirm that pottery vessels were produced locally by artisans who were a part of the Providence Bay community.

Previous suggestions that ceramics were not produced locally by Anishinaabe people are not supported in the archaeological findings from Providence Bay. The legacy of these assumptions has meant that local Indigenous communities on Providence Bay have remained largely unaware of this material heritage left by their ancestors and have not been able to participate in or revise interpretive frameworks with archaeologists collaboratively. The excavations done in the 1930s and

1980s did not involve local Indigenous communities, and the artifacts recovered were taken away: to Michigan in the former case, and to the Provincial archaeology offices in Sault Ste. Marie and storage facility in Sudbury, in the latter case. Only in the last decade has the Province of Ontario worked with the OCF to transfer the Providence Bay collection back to the community, who now are the long term stewards for this material heritage and seeking to know and interpret this record on behalf of and of relevance to their communities.

### **2.3: Digital Archaeology: An Introduction**

Digital archaeology is deeply concerned with the application of digital technologies to the display, interpretation and generation of archaeological data. Computational technology for statistical analysis and digital data storage became available to archaeologists in the 1960s, and by the 1980s it had become possible to create predictive site models (Zubrow 2006:13). Early 3D illustration programs were used in archaeology to create detailed site maps or diagrams of stratigraphy (Alvey 1993:226; Alvey and Moffatt 1986). These illustrations paved the way for the later incorporation of 3D scanning and modelling technology.

When digital technologies were originally adopted by archaeologists, they were seen primarily as a tool that could be applied to research methods already in use. The first wave of digital archaeology was characterized by quantitative research and computing. By the end of the twentieth-century, computational archaeology had shifted towards more qualitative research, though there was little introspection on the ways in which the digital tools we use can influence what we are doing. More recently, the literature in digital archaeology has shifted to consider the implications of the tools we

use and the ways in which these tools can impact our work, a stage of maturation that has been framed as the third wave of digital archaeology (Berry 2011).

3D printing, also known as additive manufacturing and rapid prototyping, emerged in 1987 for commercial use and then slowly filtered into research disciplines (Wohlers and Gornet 2014:1). The adoption of this technology to digital archaeology took significantly longer than the computational developments that came before, due to the costs associated with this technology and the commercial intent for these early printers. In the early days of 3D printing, the technology was highly cost-prohibitive, and the functionality of scanners and printers limited (Wohlers and Gornet 2014:3). 3D printing found purchase in digital archaeology by the late 1990s (Akasheh 2004; Allard et al. 2005; Carson 1997; Ioannides and Wehr 2004; Lynnerup et al. 1997; Mudge, Ryan, and Scopigno 2005).

Early concerns for 3D scanning and printing raised issues related to their use in archaeology, notably around the ethical implications of scanning and printing human bones (Carson 1997). Other issues that emerged in the adoption of 3D scanning, printing and imaging of archaeological objects and contexts were related to appropriation of Museum cultural heritage (e.g., Gillespie 2015). However, it is also fair to say that through this period, there was far more enthusiasm than caution articulated for these digital applications in archaeology and for the potential to create a wider accessibility for the archaeological record (e.g., Forte 2014; Kansa 2011; Means 2015; Morgan and Eve 2015).

With growing concerns over the implications of 3D imaging and printing on heritage displays and interpretation, some scholars have called for a more critical or

“introspective” approach to understanding both these new forms of knowledge generated digitally and the gaps that may be underexplored. Jeremy Huggett (2015:88) uses the term “introspective” to explore the ongoing shift in digital archaeology by stating:

A broader perspective of what might constitute a ‘third wave’ within Digital Archaeology is one which seeks to examine the ways in which digital technologies may have changed what we do, how we do it, how we represent what we do, how we communicate what we do, how we understand what we do, and how others understand what we do.

Huggett is calling for us to think not only about the creation of data as digital archaeologists, but also to consider how the creation and display of that content may alter the interpretive process. The ways we present data digitally can influence the level of understanding of those interacting with that data for the first time (Staley 2007; Weissgerber et al. 2015:7).

While these digital methods make new forms of analysis possible, we need to be critical of the ways in which digital archaeology reproduces and presents the past. Digital archaeology allows us to leverage technology to assist with elements of interpretation and can enrich our understanding. Still, they do not give us an unbiased window with which to know that past. We need to be critical of our own practice and the biases we may be unknowingly introducing into these digital data and representations of our work (Huggett 2017; Tsiafaki and Michailidou 2015:42).

## **2.4: 3D Modelling and Archaeology**

In recent decades archaeologists have become increasingly interested in the applications of 3D modelling in our discipline. 3D scanners use a combination of lights,



projectors and cameras to collect data, though the earliest scanners used in archaeology were primarily laser scanners that tracked data in 3D space by triangulating points in contact with a laser beam (Ebrahim 2014:1; Historic England 2018:7). While these scans were often high quality, the technology was cost-prohibitive and cumbersome to use, especially for smaller forms of artifacts. Structured light scanning later became more popular, partly due to the ability to purchase these systems at a lower cost with generally higher performance. The lower cost was a result of all parts in these machines, usually a projector and camera, being consumer-grade (Rocchini et al. 2001).

An alternative to structured light scanning has been the use of photogrammetric methods of creating 3D models from 2D photographs through a software modelling process that involves the stitching together of large volumes of photographs (Kraus 2007). In the last decade, software applications are much easier to use for this purpose, and the incorporation of phones and tablets to take photographs and create models means photogrammetry represents an easy to use and relatively inexpensive alternative option to making 3D models (e.g., Haukaas and Hodgetts 2016).

3D modelling, much like photography, is not an objective practice as it involves choice and artistic licence. When taking a photograph, there are choices made on what to include in the frame, lighting, focus and many other factors. All of these variables affect the way the subject of the photograph is displayed and, as a result, interpreted. Even with automation and standardization of practices in 3D modelling, this subjectivity is still present. For example, projecting light at a scanned object can commonly leave small “holes” in the mesh of a model once the scanning process is complete, as the

geometry, colour and reflectivity of an object can sometimes affect the ability of the scanner to fully capture surface data (Ahmed, Carter, and Ferris 2014:139) These areas of the resulting scanned object will appear as gaps or holes in a digital model.

However, in order to print from that scanned data, the 3D model must be made “watertight,” meaning that all “open mesh” must be patched. Many programs will automatically alter 3D models to fill in holes, eliminating this issue (Figure 2.4). The intent of the software is to compensate for the lack of data in the original model by assuming the hole can be filled by extrapolating the general surface geometry of the model adjacent to the hole. This process closes the gap in the model, which can be then be printed. However, it may do so in a way that may not faithfully represent the geometry of the subject, or it may fill in a gap that is supposed to exist in the object (e.g., a drill hole or punctate), or masks physical breaks or absences in the actual data, such as between sherd breaks or missing sections of an object. While the ease of the modelling software for cleaning up the scan is useful, and for many projects necessary, it is important to acknowledge the subjectivity that this stage introduces to the process.

As archaeologists, we often need to make assumptions about the past when looking at our data because the archaeological record is, by nature, incomplete. In making assumptions about that data, we are filling a different kind of hole. Instead of algorithms and software, we use a number of interpretive and assumptive knowledge bases to fill them. In many ways, the process of digital hole filling in 3D models can be seen as a digital metaphor for archaeological interpretation filling in the gaps of the archaeological record. It is critical that in using such digital applications, we are aware of the choices algorithms are making and how they potentially distort the physical record.

For some research purposes, it is just as important to ensure models remain as faithful as possible to the original object, no matter how limited. This scientific transparency has been preserved in a number of different research efforts, such as conducted on lithics and skeletal analyses (Bretzke and Conard 2012:3743; Kotěrová et al. 2019:7). But, the process of building 3D models from fragmentary and partial sherds to present the intent of the artisan, much like the process of hole filling, encompasses a number of interpretive choices. The aim is to add value and meaning beyond those fragmentary sherds, but there are challenges to get there since, much like physical ceramic restoration, digital interpretation of fragmentary vessels comes with biases. In the past, we may have been unaware of the ways reconstruction methods could be harmful to the artifacts being conserved (Koob 1998:55). In the same way, we can be potentially unaware of how digital reconstructions of ceramic vessels may bias our outcomes. The suites of software programs we use and the logic of the algorithms that shape the digital processes we follow are fixed. Our interpretations are thus influenced by the workflows the software imposes on the process.

Huggett is also critical of these workflows, noting that automated processes in 3D modelling are driven by algorithms that the vast majority of archaeologists do not understand. For Huggett, our lack of understanding is a black-box, meaning we are unable to see inside these processes to know how to be critical of our practice (Huggett 2017). These programs are not developed by archaeologists or for archaeologists, so it is difficult for us to be critical of the ways in which they may be introducing bias to our work (see also Carter 2017; Huggett 2020).

Despite these concerns, many digital archaeologists have readily embraced the range of digital archaeological approaches in the discipline as these tools increase our skillsets and make new forms of analysis, interpretation and expanding access to the record possible (Means 2017:232; Morgan and Eve 2012:529; Tsiafaki and Michailidou 2015:38–41). But they also point out that it is our job to acknowledge the ways in which we may be introducing more subjectivity to interpretation and acknowledge this in our research.

## **2.5: Collaboration in Archaeology and Community-Based Archaeology**

The current ideological shift to involve stakeholders in research has resulted in increased interest in community-based archaeology. This growing sub-discipline is focused on involving Descendant communities and key stakeholders in the process to ensure that research is “of, by, and for” the communities that can utilize this research beyond archaeology’s internal intellectual curiosity (Atalay 2012:5). Archaeology, as a discipline, has a long colonial-based history (e.g., Trigger 2006). It has only been in recent decades, as well, that Descendant communities have come to be indirectly or directly involved in archaeological practice and research, and at times these communities have been actively excluded from the research process (Thomas 2008). This legacy to practice is both unsustainable and unethical, and due to pressure from Descendant communities and a younger, more socially aware generation of archaeologists entering archaeology, notions about community engagement have evolved (Colwell and Ferguson 2008:2–4). The ideological shift towards supporting a community-based archaeology, especially over the last 20 years, has

encouraged archaeologists not just to consult but include voices previously excluded from interpreting the record (Lyons 2013).

Community-based archeology advances projects that benefit all parties involved, ensuring that community partners participate equally in shaping project design and goals (Victor et al. 2016:424). Many collaborative archaeological projects effectively work as community-based participatory research projects (CBPR; see Ansell and Gash 2007; Gray 1989; Israel et al. 2017; Tobias, Richmond, and Luginaah 2013). These forms of community-based projects tend to espouse the five principles of the “Dynamics of Collaboration,” as proposed by Management and Organization scholar Barbara Gray (1989:11-16), and archaeologists have even modelled their collaborations after this framework (Ansell and Gash 2007; Atalay 2012; Vernon et al. 2005).

As defined by Gray (1989:11-16), the core principles of a dynamic collaboration include:

1. There must be give and take among stakeholders
2. Differences among stakeholders create opportunities for growth
3. All stakeholders are equal partners
4. All stakeholders have equal control of the project's future
5. Collaboration is a process and evolves over time

Gray's work introduces some of the benefits of collaboration and suggests that the process of collaboration is “a necessary response to turbulent conditions” (Gray 1989:27). The exclusionary past of archaeology has created such a “turbulent” present, and without pressure from stakeholders and active collaboration, meaningful change in archaeological practice may never come (Sivaramakrishnan 1995:405; Sowry 2020).

While Gray is not an archaeologist, her work accurately reflects the many changes

occurring across the discipline. It is this paradigm shift that has created the growing practice of a “Community-Based Archaeology.”

This literature, especially Gray’s work, has helped frame the intentions, goals and output of this digital archaeology undertaking. According to Gray (1989:5), the objectives of collaboration should be to “create a richer, more comprehensive appreciation of the problem among the stakeholders than any one of them could construct alone.” Collaborative community-based archaeology also aims to shift practices in archaeology to make space for the voices of all stakeholders and to prioritize the use of material heritage outside of the work of archaeologists. It is the process of working together and the results of the partnership that are important dimensions of collaboration in archaeology (Greer 2010; Lyons 2013; Neil-Binion 2015). This process, according to Gray, makes a project more than the sum of its parts.

In Community-Based heritage work, engagement is not just about including stakeholders in research, but also about collaborating on an equal footing. All stakeholders contribute to the project and have the same ability to make changes. These tenets of engagement and the principles of a dynamic collaboration can be seen across a range of community-based archaeological projects (e.g., Clark and Horning 2019; Christen, Merrill, and Wynne 2017; Magnani, Guttorm, and Magnani 2018; Piccini and Schaepe 2014).

Two projects help illustrate the principles of dynamic collaboration well. First, the Inuvialuit Living History Project (ILHP) began as an effort to document materials that were taken south from the Western Arctic in the 1860s and held at the Smithsonian, known today at the institution as the McFarlane collection (Hennessy et al. 2013:44).

This research project began with a group of community and institutional researchers working together to bring the knowledge of the collections back to Inuvik in 2009 (Hennessy et al. 2013:45). Photographs were taken and used to populate an extensive online database accessible on the ILHP website (Hennessy 2016:115).<sup>1</sup> All photographic and archival data from the MacFarlane collection is complemented by the interpretation of these objects and additional research by community knowledge holders that are equal partners on the project. Hunters, woodworkers and seamstresses were able to interpret collections of objects related to their specific expertise, which enriched the published interpretations (Hennessy et al. 2013:44–50). Today, the ILHP continues as a collaboration with Inuvialuit community members to promote access to Inuvialuit cultural heritage in and out of the Inuvialuit Settlement Region. The continued engagement of the community with institutional researchers as equal partners has allowed the project to continue pursuing their goal of increasing accessibility to and appreciation of Inuvialuit Cultural Heritage.

The Mukurtu CMS project is another open-source, digital-heritage initiative that allows Descendant communities to dictate access protocols for digital heritage information (Christen 2012; Christen, Merrill, and Wynne 2017). The project began in 2007 as a collaboration between faculty at Washington State University and Warumungu Elders in northern Australia, with the goal of assisting the community with promoting appropriate use and access to a large volume of archived photographs of cultural practices. The Warumungu Elders were particularly concerned that photographs in the collection needed to be restricted (e.g., women's sacred items and

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<sup>1</sup> <http://www.inuvialuitlivinghistory.ca/collection>

practices should not be viewed by men, and vice versa). To address this concern, a custom API was developed with the Warumungu community that made archived photographs available only to registered users that met relevant screening criteria. The API ensured users could create accounts and browse the archives in a culturally appropriate manner. In this virtual environment, the social protocols of the community are prioritized over the archiving protocols of the research institution.

Following the completion of the team's original partnership, the Mukurtu CMS was made freely available in hopes of allowing other communities, researchers and collaborative projects to manage digital materials according to their specific needs. There have since been yearly updates on the Mukurtu CMS Github page, along with smaller bug fixes in-between, indicative of an active maintenance of the code (MukurtuCMS 2019). Today the Mukurtu CMS has been applied to other projects to assist teams working with cultural archives that have a need for customizable access protocols (Hall 2018; Shepard 2014:316).

Both of these projects are excellent examples that reflect heritage initiatives prioritizing the needs of all parties, and an ultimate goal of serving the particular needs of the community. As heritage professionals, our work can be meaningful to communities. In my view, heritage is not meant to be locked away in boxes or academic literature, and as a result, I believe community-based heritage initiatives are very much the future of this discipline.

## **2.6: A Digital Community-Based Archaeology**

Recent initiatives are working to blend digital and community archaeologies to create digital projects that engage with and are shaped by communities (Dawson, Levy,



and Lyons 2011:393; Magnani, Guttorm, and Magnani 2018; Younan and Treadaway 2015:240). Often these projects are geared towards improving access to heritage material or information for both communities and researchers. The barriers to accessing digital heritage are often lower than accessing physical objects, and because of this, many digital archaeologists and others working in the digital-humanities praise these methods for their potential to be equalizers.

One example of a project of this nature is the partnership between the Sami community and the Sami Museum Siida (Magnani et al 2018). The goal of this partnership was to increase access to heritage materials held at the Museum for members of the Descendant Sami community. Previously, archaeology had collected information and material culture purely for academic purposes, without consulting the Descendant community. The initiative of this project was to be disruptive of these old practices. Photogrammetry was used to create 3D models of several heritage items (Magnani et al 2018). The 3D models were of particular interest to community members as these objects were vital to allowing local artisans to use the information from the digital models in their efforts to revive traditional ways of making these objects.

A combination of ethnographic and digital archaeological methods were used to make it possible for community members to gain access to these digital models in ways meaningful to their needs. At the conclusion of the project, the models were published online for the community to access, while the methodology used was published so other projects could achieve the same goals as this project.

Digital collaborative projects include many voices and perspectives to inform the work they engage in, and ultimately their results, offering a unique means of bridging

archaeological research with the interests and priorities of Descendant communities wanting to interpret and access their heritage. Such initiatives do not imply that this form of research is better than conventional academic scholarship. Instead, the focus is on the broadening research that benefits all parties involved (Lyons and Martindale 2014). The goals of collaborative research are to produce an interpretation that has more perspectives included or to tell a more detailed story (Lippert 2008). This growing body of a community engaged digital archaeology has the potential to further this broader trend in archaeology, and this thesis hopes to contribute to that advancement.

## **Chapter 3: Collaboration and Collaborative Methodology**

### **3.1: Definition of Collaboration**

The goal of this thesis was to work within a collaborative process to develop digital content that could be both a teaching tool and displayed in a gallery space. Anong Beam and I worked together to ensure that the priorities of the Ojibwe Cultural Foundation (OCF) and my MA thesis were addressed in this project. Those priorities were primarily concerned with the ways this project could best serve the needs of the OCF and their community, while exploring applications of digital technologies to the research questions we developed together.

By collaborating, we were all working together to recognize the ways in which our skillsets could complement one another. Even though I was working to complete the requirements of my MA, and Anong was specifically looking to deliver content for OCF programming, we shared a desire to learn more about ceramics at Providence Bay by interrogating the ways in which digital archaeology could be utilized to make this archaeological record more accessible.

### **3.2: Origins and Project Background**

The Providence Bay archaeological collections were on loan from the OCF to Dr. Neal Ferris, and temporarily housed at the Museum of Ontario Archaeology's (MOA) collections repository. The loan was to facilitate opportunities for research about Providence Bay and the life and material culture of the people who had lived there that would help the community better engage with and come to know their ancestral heritage.

The First Nations communities on Manitoulin Island have long sought to control and access their archaeological record for their benefit (Manitowabi 2001). More generally, archaeologists have been criticized for conducting and producing research that is not accessible to those outside of the discipline, and data that becomes locked away in grey literature (Gould 2016:12; Selden & Bousman 2017:6). These practices are often not the ideal situation for Indigenous communities who can only access that record through jargon-heavy reporting, while collections of material heritage are too sterilized and removed from past human experiences to be meaningful for those outside of the discipline. It is this unique challenge that community-based archaeology is interested in addressing.

Anong had concerns about ongoing Providence Bay research and wanted to ensure that any new research that was to come from a partnership with researchers at Western would be meaningful to the community and in line with the goals of the OCF. At the same time that these conversations were happening, I was beginning my MA. I had previously worked at the Museum of Ontario Archaeology as a 3D technician that produced models for research purposes and had completed reading courses focused on digital archaeology. My primary goal as an archaeologist was to find a way to take these skills and apply them in a way that would be meaningful to those viewing my work.

In our first conversations, Anong was most interested in seeing research done on the Providence Bay ceramics so that the community could learn more about the pots made at the site rather than the sherds left behind. Anong wanted to see a pot modelled from fragmentary sherds to gain a better understanding of the shape of vessels. She

also explained that having a 3D printed model informed by the recovered ceramic sherds from Providence Bay would be a helpful guide in upcoming ceramic making workshops the OCF was running. A modelled and printed pot would allow community participants to see the shape of the vessel and even feel the thickness of its walls. The ability to give patrons and learners at the OCF a hands-on learning experience was very much in line with the OCF's goals.

Between the Summer of 2018 and 2019 Anong and I had several conversations that allowed us to generate the first digital model of an Anishinaabe pot from Providence Bay. The partnership we engaged in made our project different from previous archaeological endeavours on Manitoulin Island by shifting the focus of our research from categorizing artifacts to prioritizing the needs of the community. Our time together allowed us to find a way to leverage digital archaeology to service the needs of non-archaeologists. Digital archaeology gave us the ability to translate the archaeological record into something that could be utilized by the OCF and, ultimately, the community.

### **3.3: Dynamics of Collaboration and the Development of the Heart Pot and Aahnkesjihgeh Method**

As discussed in Chapter 2, Grey's (1989) framework on the dynamics of collaboration will be utilized here to frame the collaborative process in scholarship more broadly and as experienced through our project. Collaborative work often means seeking common ground and attempting to bridge conflicts and differences between participants (El Khouly & Amer 2013; Hong 2016; O'Leary & Vij 2012). While Gray's work provides an outline for talking about some of the most fundamental aspects of collaboration, it originates from organizational management and within the logics of corporate or governmental collaborative frameworks. In projects of this nature, the

collaboration aims to work towards a single solution to an issue that multiple parties share stakes in.

This form of collaboration is distinct from undertakings where the complexity of navigating collaboration is not to work to a single project goal, but to allow space for the distinct perspectives and aims that come from a diversity of voices working alongside one another. This more complex form of collaboration is what a community-engaged archaeology strives to achieve.

Collaboration with Indigenous communities requires archaeologists to be conscious of the multiple ways of knowing the past and the priorities that exist between researchers and community partners. These collaborations braid worldviews through the process of working together as discrete but bound parts of a whole. In corporate contexts, the aims of collaboration can be to amalgamate goals and ensure that the final product developed is better than the sum of its parts. However, when working with heritage, there may be no actual “product,” as the intangible aspects of heritage are inseparable from the artifacts themselves (Alivizatou 2006:50; UNESCO 2003:4).

Nonetheless, the five stages and dimensions of collaboration that Gray (1989:11-16) has outlined in her work I found helpful in framing my collaboration with the OCF. These stages are an excellent starting point for understanding some of the basic elements of collaboration. Below, the deeper exploration of archaeological collaboration and my partnership with the OCF is juxtaposed within Gray’s framework to explore the complexities of a community-based archaeology. Our collaboration was not about finding a single way to understand the past, but about finding novel ways to interpret

and present archaeological information, making it possible for us to visualize the past in a way that neither of us had done before.

### **3.3.1 Collaboration Implies Interdependence**

Gray uses the word interdependence to refer to how stakeholders are bound to one another through a shared goal or intent. For a collaborative partnership to work, give and take among the stakeholders is necessary to balance diverse viewpoints and priorities, facilitated through extensive communication where all voices are valued (Aas, Ladkin and Fletcher 2005; Atalay 2019; Bronstein 2003; Horning 2019).

Interdependence therefore means that all collaborators are equals and, through collaboration, contribute to the decision-making shaping that process. This shared decision-making is important as it facilitates the imagining and development of goals, the development of a common language for the project to bridge different perspectives and priorities, and also provides a much-needed opportunity for all partners to become aware of the challenges that they individually may not have been aware of otherwise (Chilton 2012; Long 2015). This awareness is especially important when leveraging digital technologies in a collaborative project, given that all partners may not have the same level of expertise or understanding of how these technologies work.

The form and direction of a collaborative project is shaped in these early interactions. These early stages also provide participants with a first glimpse into the ways in which a project can be enhanced beyond preconceived notions by working cooperatively. These early communications create a road map for the work that follows.

After I began working with the OCF and Anong directly, we had a chance to discuss the expectations we each held for our partnership. It was critical to the OCF to ensure that whatever we did together would, in some way, benefit the community. What was clear from those early discussions was that, while the OCF was aware that extensive archaeological fieldwork had been carried out at Providence Bay in the 1980s and 1990s, that work was largely done without engaging the Indigenous communities of Manitoulin Island. Afterwards, there was no real sharing of the findings, or interpretations, or even descriptions of the archaeology published. As well, what little information was available was not easily accessible for community members due to these studies being behind paywalls or only available in jargon-heavy field reports and dissertations, making them inaccessible to anyone outside of archaeology (see also Kansa 2012:499).

The existing studies on the Providence Bay site enhanced an archaeologist's understanding of the site and Anishinaabe material history. One such project was the Hancock et al (1993) study of copper and brass from archaeological sites in northeastern Ontario. They were able to demonstrate that the majority of copper artifacts from Providence Bay were made from indigenous copper sources from the Great Lakes, not from European trade goods. This study corrected the previously held assumption that all copper use at Providence Bay and by Indigenous communities around Lake Huron was a European innovation of the seventeenth-century.

But this research was not community-driven. It happened by and for archaeologists to address archaeological research interests. The OCF's primary desire going forward, then, is to ensure that further research on the Providence Bay site and



collections align with their goals, ensure that the OCF participates in that research, and by doing so, ensure that knowledge and insight gained of this heritage is of benefit to the local communities.

Upon starting my MA, I was primarily interested in the ways digital archaeology could make the archaeological heritage accessible to community members and in a way that was more immediately meaningful to non-archaeologists. My previous experiences with practicing digital archaeology had led me to spend a considerable amount of time thinking about this practice. And while I wanted to interrogate it further, I also wanted to avoid a project that was highly technical or otherwise focused solely on methodology.

There has been a significant body of digital archaeological research focused on experimentation with the technologies and methodologies developed from other fields of research (Beale & Reilly 2017; Huggett 2014:16; Saracino et al. 2018). This research had been important in generating novel methodological advances in digital archaeology and, as a result, for archaeology more broadly. I wanted my research to engage with these advances in a way that was meaningful outside of the discipline. So I explored the ever-expanding work in community-based and collaborative research in archaeology, and more specifically, digital archaeology (e.g., Escobar 2018; Glencross et al. 2017; Grieve 2019; Haukaas & Hodgetts 2016; Lyons et al. 2016). Any digital archaeological research I wanted to pursue would need to be done with partners, and the output of that research would need to be an application of digital archaeology with their priorities in mind.

Anong had previously expressed to Dr. Ferris that, to her, archaeology focused too much on describing and grouping artifacts, or at least failed to show to people who

are not archaeologists how those descriptions and groupings fit together to describe the lifeways of people in the past (Beam & Brooks 2018:24-25). So early on in our discussions, Anong indicated that she would like to see the fragmentary ceramic sherds found on the site be put together somehow so as to give a sense of what the original pot they came from looked like, to give a sense of what the heritage of the craft of pottery making was from Providence Bay.

An OCF programming initiative that Anong and others were developing at the time included teaching material craft and heritage to OCF workshop participants. Anong explained that it is extremely challenging to teach ceramic making, especially traditional methods, from the archaeological findings at Providence Bay. While there was one partially reconstructed vessel assembled from the Providence Bay collections, it was fragile and heavy, making it unsuitable for teaching purposes. What would be more valuable was having an exemplar that learners could touch. Anong wanted the participants of this workshop to experience a vessel that was tactile and engaging while conveying the vessel fragments found by archaeologists in a way that taught all patrons of the OCF about the form of Providence Bay pots.

When we began talking, Anong was already familiar with the fact that I had the technical ability to create digital 3D models of artifacts and that I had previously undertaken a project with Dr. Ferris where I successfully had digitally mended together two sherds of a broken vessel and then printed that model. Right away, Anong was interested in the possibility that a 3D rendering and print of a vessel digitally modelled from Providence Bay ceramic sherds would be an exciting way of engaging beyond the bits of archaeology. My abilities in digital archaeology to possibly actualize a goal of the

OCF was something that we were excited about in these early stages of discussion, and that excitement shaped the direction the project took from that point on.

Gray (1989) describes interdependence as a give and take between stakeholders that make it possible for them to achieve more than they could independently. It is also the way in which collaborative partners come to know the perspectives and abilities of each other. In our project, Anong and the other OCF staff I worked with as partners had a wide range of ideas for the direction they would like to see research on the Providence Bay site collections take. My skills were not in faunal analysis, interpreting past lifeways or even ceramic interpretation, but rather in digital archaeology. It was this expertise that shaped the direction of our partnership. The possibility of making the material heritage of Providence Bay more accessible digitally was something that the OCF saw as a novel way of meeting their needs. Early on, Anong and I had several conversations where we considered different ideas about what might be possible for this project. But the major theme that we continuously returned to was the creation of a 3D print of a modelled pot. The initial stages of this collaboration highlighted the ways in which Anong, the OCF and I shaped an aim and goal for this project that could only have emerged from our collaboration.

### **3.3.2 Solutions Emerge by Dealing Constructively with Differences**

The differences that exist between research partners offer a great deal of creative potential. According to Gray (1989:11-12), it is communication about these differences that allow us to learn more collaboratively than it would be possible otherwise. Scott Page (Hong & Page 2004) demonstrated the boost given to work when it is done in teams of diverse thinkers solving complex problems. This boost is because

groups are made up of research partners that would otherwise take different approaches to solve problems. Page (2017) has referred to the factors that create this effect as “cognitive diversity” and “functional diversity.” He argues that working in groups of diverse thinkers is best when the problems they are working on are both “cognitive and non-routine,” meaning they require a high level of expertise to address, so work cannot be standardized (Page 2017:39). These sorts of tasks need problem solvers to be highly skilled in their respective areas of expertise and also be able to adapt to continually variable work expectations. For Page (2017; Hong and Page 2004), this need for a high level of expertise, coupled with an adaptive and flexible approach in collaborative contexts helps us gain a more well-rounded picture of the complex work we undertake together.

Page (2017) argues that in fields requiring a high level of cognitive and functional diversity, working collaboratively is essential. Collaboration is needed because the bodies of knowledge across and within these fields are far too vast for one individual to master fully. By collaborating, we work with people that have different priorities and concerns but share an understanding of the task at hand and can collectively achieve something more. Gray describes this phenomenon much like the allegory of blind men, working together, to discover an elephant. Each individual has something different to contribute, and by combining perspectives, a more complete picture of the problem to be solved is achieved (Gray 1989:12).

Also, by contributing, each team member is making a personal investment in the project. Gray states that “the process of collaboration builds in certain guarantees that each party’s interests will be protected” (Gray 1989:22). These guarantees give

collaborators a sense of belonging because everyone has invested their time and energy into the project.

Collaborative partnerships in fields like archaeology can be more complex than workplace collaborations. Archaeologists have a distinct way of knowing the past through their interpretation of the archaeological record. This record also encompasses Descendant community heritage and intersects with Indigenous worldviews, distinct from Western systems of knowledge. These differences require accommodation and equal footing when undertaking collaborative work. In this form of collaboration, then, braiding archaeological and community worldviews creates a common ground and space where different ways of knowing can exist and together and work on equal footing (Atalay 2019; Dion 2009).

I came into this project with skillsets, worldviews, and my understanding of Providence Bay archaeology. The OCF aims to preserve and nurture the expression of Anishinaabe culture in all forms so that they flourish and remain vital for future generations.<sup>2</sup> Anong's interest in pottery made her uniquely interested in the archaeological ceramics from Providence Bay and brought a potter's knowledge about the process of manufacturing ceramics to this project. As the material heritage from Providence Bay had not previously been shared with the community on a wide scale, a project where we would develop a novel way to present archaeology to the community was in line with the OCF's goals to nurture and preserve Anishinaabe culture.

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<sup>2</sup> <https://ojibwe-cultural-foundation.myshopify.com/>

In our discussion about the collections, Anong taught me many things about how ceramics could have been manufactured on Manitoulin Island, since she had previously experimented with creating her own reproductions of Providence Bay vessels using only materials that would have been available to local artisans. For example, in one of our first conversations about the ceramics themselves, we discussed the sand temper in the clay fabrics visible in the sherds from the site. While I was familiar with the role temper plays in ceramic making, I had not closely examined the temper in the Providence Bay ceramic assemblage. Anong had observed that a significant number of sherds in the collection had a visible sandy temper, which she speculated was likely Providence Bay beach sand. The implication being that the pots were made on site. This interpretation was a logical conclusion given the appearance of the temper and the proximity of the site to a large beach. However, it was not an assumption that felt as “natural” to me as it did to her, since the archaeological ceramic studies I had read tended to emphasize stone grit, rather than sand, as the most common temper used in pots.

As a result of our discussions, my interpretation of the ceramic record at Providence Bay was enhanced. While Anong and I both had knowledge of temper and ceramic manufacture, I did not have the practical, situated experience of a potter and being on Manitoulin Island to see the connection between the sand, the site, and the temper. Much like Page and Grey describe, by discussing the ways in which we each understood the ceramic record, we were able to get to a more complete picture of the process of ceramic manufacture at Providence Bay.

Anong and I had several conversations about pottery making and the goals for this research, and it became my job to implement these discussions into the research

design of the project moving forward. In the initial stages of our communication, Anong and I considered what could and could not be possible. In these conversations, we became aware of the different expectations we each held. For example, upon beginning my graduate studies, I had been very interested in recent literature exploring the application of virtual and augmented reality to both the interpretive processes in archaeological research, and making that research accessible to non-archaeologists (e.g., Berggren et al. 2015; Carter 2017; Dawson, Levy, & Lyons 2011; Webb & Buchanan 2017). These projects are unique in that they provide immersive experiences for viewers, which allow for a more interactive engagement with the archaeological past than compared to objects sitting in museum display cases (Cook & Compton 2018; Galeazziup & Di Giuseppantonio Franco 2017). While this is a growing literature I was keen to explore, the direction that research would have taken me did not align with the OCF's interests and the ideas presented in our early discussions.

In early discussions about this project, our expectations shifted as our sharing of knowledge created a more robust vision of what we were willing and able to undertake, share and learn from each other. The needs of the OCF influenced my interests and the technical methods I would investigate to accomplish these goals. Page (2017:68) discusses this effect, stating that "On complex tasks, no single person's repertoire will be sufficient," indicating the ways combining knowledges and understandings can enrich a project. I would never have been able to build up a lifetime of knowledge of making pottery, so communication with Anong added a crucial perspective to the project that increased what was knowable about the heritage of pottery making at Providence Bay.

Following these initial conversations and early project planning, I crafted two research questions to assist us in refining the aims of the project further:

1. How can we take what we know from the archaeology of Providence Bay and fragmentary ceramics sherds and make that knowledge more accessible to non-potters and non-archaeologists using the methods of digital archaeology?
2. What is the most applicable medium and method for presenting this information?

These questions will be expanded upon further in chapter 4.

### **3.3.3 Collaboration Involves Joint Ownership of Decisions**

Grey's (1989) framework states that all partners should be directly responsible for and involved in decision making. In a true collaboration, there is no single authority holding all the decision-making power. Instead, all decisions are made collectively. According to Grey (1989:13-14), there are three necessary steps in decision making for effective collaboration:

1. Research should be undertaken together;
2. Decisions arrived at in these partnerships will meet the needs of all collaborators and be agreed upon unanimously;
3. Plans made to reach these mutually beneficial goals must be actionable by all partners.

Because team members have different perspectives and priorities, it is only through communication that research questions meaningful to all parties can be developed and decisions around goals identified. Understanding shared goals is what sets the stage for a shared division of labour. Lastly, it is not enough to be about creating these goals in collaboration. All plans must also be realistic and actionable by all partners.



Sonya Atalay's (2012) research on Community Based Participatory Research (CBPR) in Indigenous archaeology explores this notion of joint ownership and authority in decision making. Indigenous scholars have pointed to the historical lack of community consultation in archaeological research as a major gap in project development and long-term stewardship (e.g., Hedeba, Greer, and Mackie 2012; Mills et al. 2008; Watkins 2005). Atalay (2012) suggests that CBPR can help address some of these concerns, countering past arguments by archaeologists that the inclusion of other ways of knowing in archaeological discourse would reduce the scientific validity of that work (e.g., Cutler 1970; Mason 2006:150; O'Farrell 1979).

Other archaeologists (e.g., Clark & Horning 2019; Ferris & Dent 2020; Harris 2005; Stump 2013; Zimmerman 2005) have argued that multiple ways of interpreting the material heritage of archaeology has the power to strengthen our understanding of the past, or should at least make room for other ways of knowing to exist alongside archaeological interpretations. For example, an ongoing research partnership that exemplifies this approach is the Champagne and Aishihik First Nations (CAFN) efforts to learn more about Kwäḍāy Dän Ts'ínch'i (Long Ago Person Found; Beattie et al. 2000; Hedeba, Greer, & Mackie, 2012). Since the initial discovery of Kwäḍāy Dän Ts'ínch'i, the CAFN has been reaching out to scientists to learn more about this ancestor. The community was able to dictate the protocols that the partnership would follow, and all research was designed and undertaken at their request. This partnership proved to be a highly informative and positive endeavour as it created a bridge between the institutional academic community and the Descendants who had a desire to hear input from the scientific community (Hedeba et al. 2012:58).

In partnerships between scholars and communities, adopting multiple perspectives invites the incorporation of multiple worldviews and experiences beyond those held by a single researcher. Atalay (2012:74; see also Nicholas 2008) suggests that this work, done “with, by and for” Indigenous communities, creates equitable partnerships and mutually beneficial research projects. The design of research projects involves a considerable amount of discussion and shared decision making and avoids stripping Indigenous communities of their autonomy over their heritage (Asch 2008:394). Archaeology is very much an interpretive process that presents the world with narrative representations of the past. Those narratives increasingly need to be for more than just the intellectual curiosity of archaeologists.

The OCF has previously worked with archaeologists regarding the material heritage on the island, including mixed experiences over the joint stewardship of the designated Sheguiandah site (e.g., Julig 2002), but generally, there has been an absence of engagement (Brooks and Beam 2019). As a result, this project was the first opportunity to develop research questions in a collaborative partnership beyond the intellectual curiosity of archaeology and academia.

Since we had agreed that pottery sherd fragments are difficult to understand as heritage without a deeper understanding of pottery manufacture and shape, we had come to the notion that digital methods could offer us the means to virtually model and convey pottery vessel forms from those sherds. Anong and the OCF were excited about digital representations but also felt that a tangible, tactile object would be a more effective tool for conveying the connection between pottery sherds, pot forms and making pots. So, we all felt a printable pot would be the way to address the goal for this

project. I would be responsible for developing a method and creating a model of a pot, while OCF staff would provide me with feedback on the various iterations of the model to inform subsequent revisions.

### **3.3.4 Stakeholders Assume Collective Responsibility of the Project's Future**

All collaborative work must extend beyond planning and execution. When the last stages of a collaborative project have ended, plans must be in place for what happens next. To Gray (1989), this means ensuring that the output of the project is protected. This protection can take many forms, such as planning for the future maintenance of infrastructure, protecting access to research data, planning for a re-evaluation of the project outcomes, and other such efforts (Gray 1989:276-277). All research partners need to be equally responsible in planning for that future stewardship that ensures the efforts or outcomes generated in the process of collaboration will be cared for (Gray 1989:271). Gray (1989:20-23) states that this future planning is especially important since collaboration does not simply end on the last day of a project. Collaboration means ensuring all parties are satisfied with the efforts taken to care for the shared goals that have been reached as a result of that collaboration.

Collaboration is challenging. But we also need to ask ourselves what the implications of our work as archaeologists will be, post-collaboration. Engaging with and interpreting heritage is a process of meaning-making that has heavy implications for the Descendant communities affiliated with that heritage. Because of these implications, the long term stewardship and accessibility of that knowledge, in whatever medium it takes, is extremely important (Labrador & Chilton 2009; Staiff 2014:29–33). If there is not sufficiently planning, collaborative efforts can be undermined.

Nicholas et al. (2010) compiled a list of critical questions related to the growing body of collaborative research in archaeology. They assert that the collaborative process cannot ethically end when all writing has been completed. Instead, we need to consider: “Where will the research go? Will it be archived and if so where? Who will have control over it? How will it be accessed in the future? What permissions for use now and in the future need to be developed? Who can speak for this material? How will any future rights be negotiated?” (Nicholas et al. 2010:128).

It is telling that Nicholas et al. are concerned with the implications of archaeological research *following* publication. Archaeology’s long colonial history has often left community partners in uncomfortable positions resulting in understandable tension and mistrust of research practices (Atalay 2008:30). Implicit through these discussions is that collaborative efforts need to enhance community partners’ capacity to further manage and decide about their archaeological heritage after academic partners have moved on. Asch puts this well when he notes, “What could be more reasonable than a desire to ensure that you are the custodian of your own cultural heritage” (Asch 2008:394; see also Warrick 2017).

In our discussions, Anong and the OCF felt early on that a key outcome of our project would need to be in keeping with the goals of the OCFs ceramic-making workshops. This aim meant that a virtual-only model would not be sufficient and that we would need to generate a tactile output as well. As a result, we began planning for a 3D printed vessel that would be used at the OCF. After all, as a process, pottery making is an extremely physical, tactile experience and learning process (e.g., Crown 2007). A printed model of a pot that participants would be able to touch and hold would provide

them with a valuable opportunity to engage with the Providence Bay ceramics beyond artifact fragments and begin to think about ancestral pottery manufacturing techniques in a hands-on manner. It would also remain a tangible output going forward after the end of our project.

We also discussed our research efforts and what that could mean for future investigations into the Providence Bay site. For example, we talked about ownership and the long-term stewardship of the digital and printed materials generated for this project. As the model and eventual print that we were producing was going to be an interpretation and representation of Providence Bay ceramics, it seemed logical that it would be the sole property of the OCF. While I did develop and build the model, it was not intended to further my research aims after this thesis was completed. The pot was created to learn about the heritage of Providence Bay ceramic craft and to teach future patrons of the OCF about ceramics.

In my discussions with the OCF, we also talked more generally about the digital research and methodology I would develop for this project. We agreed that the methodology I developed should be our shared property. There are many existing options I could have adopted for producing a digital model of a ceramic vessel; however, many of them felt incompatible with our long-term goals. Some software programs are proprietary and expensive, and many are not at all user friendly for novices. While I may have been familiar with some of these software options and workflows, and may have been able to use them in this research, they would have been much more challenging for the OCF to use to continue our work in the future, at least without someone well-versed in 3D modelling to work alongside them.

These concerns for the future research potential of this project led us to pursue the development of a novel method of object modelling that would utilize exclusively open-access software. The methodology would aim to offer an open-access pathway for reconstructing ceramics in the same manner in the future. If fully successful, the method adopted here would also make it possible for the OCF and community to expand their efforts for working on the Providence Bay collections without involvement from archaeologists.

### **3.3.5 Collaboration is an Emergent Process – Towards the Heart-Shaped Pot and Aahnkesjihgeh Method**

As has been stated throughout this exploration of collaborative research, the dynamism of the process must be constant. Collaboration cannot be prescriptive; the process needs to embrace the flexible nature of the engagement in the development of research questions, design of the project, and goals for the outcome. This fluidity is not always preferable in academic research contexts due to the longer investment in time needed to develop meaningful collaborative relationships. Despite these challenges, it is worth the effort. Gray (1989) argues that the additional effort yields a significant return as chances of needing to revisit or cancel a collaborative project are reduced. This approach is even more important in archaeology as the communities and people whose heritage our work is in the service of deserve to be a part of that decision-making process (Ferris & Welch 2014:231). Archaeology should never be uninvited.

According to Gray (1989:15), the collaborative process must begin unorganized, with active participation from all parties. This lack of structure allows a project to take shape in the direction best suited to the concerns and interests of all partners, and in the process finding the space needed for separate priorities to be consensually braided

together. Gray notes that, at times, it may feel impossible to achieve this end, as the goals of many parties can often be opposed or appear non-complementary. In archaeology, communities may not feel they can trust their heritage in the hands of archaeologists due to the discipline's colonial past (Atalay 2008:31; Lonetree 2012:123–126). This mistrust is grounded in over a century of the discipline not accounting for the needs and desires of Descendant communities. That legacy is something that itself needs to be worked through early in new collaborative projects. If dynamic and collaborative research is to be achieved, it must be seen to be responsive to and in line with the goals of the community. Gray's framework illustrates that a lack of pre-expectations, equal and active participation, and a willingness to compromise all creates a valuable and lasting result for all parties involved.

Mills et al (2008:32-33) outline a partnership that existed between the University of Arizona and the White Mountain Apache Tribe that utilized the collaborative process to teach future archaeologists about working in a dynamic research environment. While the partnership had existed before the expansion of their work and the creation of the field school, both parties felt the need to engage more deeply to help address concerns related to previous research that had not been beneficial to the community. Greater "costs" were associated with working this way as there was a much greater time demand. However, in the end, the field school was able to more directly meet the community's goals and ensured learning outcomes integrated both academic and community-based insights and knowledge.

For this project, I needed to complete a research proposal as per my degree requirements. However, the OCF and I stepped away from the specifics of that proposal

not long after our first discussions. I was aware of this dynamic nature of community-engaged work, so I was not surprised to see this shift once our collaboration started to take shape. Following these early discussions, the OCF and I began shaping what would become the heart of this project: the design and development of a novel digital methodology and a 3D printed model intended to service the OCF's interests in preserving and nurturing Anishinaabe cultural heritage generally, representative of the archaeology of Providence Bay specifically. In other words, an Indigenous, community-based, digital archaeology application.

In the winter of 2019, Anong and I spent three days at the OCF working together and discussing the application of 3D modelling to our research goals. Before this point, we had spent a substantial amount of time talking about the ceramics from Providence Bay. But being able to work side by side and discuss the project as the first digital models were constructed gave us a valuable opportunity to learn from the digital process together. Anong set up a work corner for me and continued to go about her day at the OCF as she usually would. I began the first preliminary builds of a pot model using measurements from "Algoma Lipnotch Vessel 97."

Following the first digital build, I was able to show Anong a rough estimate of the original form of the pot. Doing so was the first opportunity for both of us to get a sense of how the method I was developing worked at taking limited data from highly fragmentary vessel sherds to inform the modelling of a vessel. Anong's immediate impression at seeing the first effort was to note that the vessel was "heart-shaped." This preliminary digital approximation immediately resonated for Anong in a way a bag of ceramic artifact sherds could not, underscoring how conceptually removed artifact



sherds are from a vessel's form, and how that original artisan intent and practice is better captured and visualised within a vessel's form, not its fragments.

All of our discussions before and during my digital work at the OCF made it possible to work collaboratively in real-time, incorporate feedback and actively revise the process. Before I had left the OCF, we had created a first draft of our "Heart-Pot." Embracing the fluid nature of collaboration in this context allowed me to receive feedback on the shape and form of the vessel and implement that feedback into subsequent iterations of the model I developed. It also allowed for the formation of a distinct digital archaeological method to emerge through this fluid collaboration.

Collaborating this way also led us to discuss how we could capture this collaborative method as something distinct from an archaeological terminology, since Anong had mentioned that many of the academic terms assigned to the heritage of Manitoulin Island were not meaningful to her or community members. I also wanted to refer to our methodology in a way that reflected the process we had engaged in and the place our work came from. Anong suggested the name "Aahnkesjihgeh," as it means "pattern making" or "puzzle-solving" in Anishinaabemoin. This term seemed to resonate with the OCF's goals and the methodology I had developed through our collaboration. As a result, the OCF Aahnkesjihgeh Method, to digitally recreate and print the Providence Bay Heart-Pot, emerged from our fluid process of collaboration and digital creative process. See Appendix B for a detailed review of this method.

In many ways, the original goals defined for this project have been addressed however, Gray notes that in a true collaboration, there always will be follow-up work necessitated by the needs of that collaboration. While I have delivered the products, I

had committed to developing, I have also been asked to present my research at the Centre. There have also been requests for the ceramic sherds I used to build the Heart Pot to be returned to the OCF ahead of the rest of the collections for display purposes.

These responsibilities remain mine to fulfill, though they are not requirements of my MA. They are instead requirements of the collaborative process that I am a part of and concerned with. So, I will ensure they are met to the fullest degree possible. A true collaboration does not *really* ever end. Instead, it spiderwebs out and requires an ongoing investment going forward. This investment cannot be fully anticipated at the outset of a project, but researchers engaging in collaborative work must be aware of this ongoing process beyond their project specifics.

### **3.4: Conclusion**

In this project and the many others discussed above, collaboration enriched and enhanced the work conducted. Page (2017:86) argues that this is because “one plus one equals three because each new idea contributes on its own and in combination with the others.” But it is not only about what each team member has to offer; it is about how each perspective, priorities and distinct worldviews and experiences will enhance the collaborative output. Working collaboratively makes it possible for archaeological research to interpret archaeological and heritage data in a way that is enriched by multiple perspectives. It is no longer just an ethical choice to engage with community members and stakeholders, but a responsibility that must be recognized before work begins. Archaeology is deeply involved in heritage, and because the record archaeologists produce is the heritage of communities, it is our ethical responsibility to ensure that the work practitioners do in the service of communities properly engages

with them and makes space for their values and perspectives (Canadian Archaeological Association; Canadian Archaeological Association 2019; Ontario Archaeological Society 2017; Society For American Archaeology 2016; The Ontario Archaeological Society 2003).

In our case, the collaborative process provided the OCF and myself with multiple opportunities to revise and further enrich our work. I would not have had a sufficient understanding of the process of ceramic manufacture to make a comparable model to the Heart-Pot without Anong's insights. The OCF would not have been able to develop and 3D print the reconstructed Heart-Pot without my digital archaeology abilities. Regular conversations mixed with real-time feedback at various stages of the project allowed us to better braid our goals, methods, insights, as well as the resultant output, as detailed next in Chapter 4.

## **Chapter 4: Digital Archaeology and Digital Methodology**

### **4.1: Introduction**

The Aahnkesjihgeh method developed for this project produced a low cost, accessible, and simple way to create digital composite ceramic vessel models for display. These digital models can also be 3D printed, creating objects suitable for both gallery and educational applications. This work was done in collaboration with and for the OCF. Due to the comparatively lower learning curve associated with this method, it is possible for other heritage institutions and professionals may wish to replicate the process or use the results of this project for their own purposes.

Previously in Chapter 3, I reviewed the collaborative process that informed our decision making. This chapter will explore how those conversations and decisions informed the digital choices made in undertaking the 3D scanning, modelling and printing steps, and the ways in which our collaboration enhanced my ability to create something specifically suited to the needs of the OCF.

### **4.2: Research and Development of a Digital Archaeological Framework**

The ceramics from Providence Bay are represented by collections of highly fragmentary sherds (see Figure 4.1). The physical state of these sherds makes it a challenge to display them in a gallery setting, share them with community members, or convey the original artisan's craft from objects that cannot on their own convey the original shape or design of the vessel. As such, the OCF's goals of learning from the Providence Bay archaeology needed a method of translating artifacts into tangible objects, heritage and Indigenous lifeways. My experience in digital imaging and modelling archaeological objects could help achieve the goal of being able to share the

traditional craft of Anishinaabe pottery manufacture with patrons of the OCF. This method is a lower risk for the artifacts than attempting a physical reconstruction of a vessel (e.g., Rodgers 2004), and certainly was not possible for the very fragmented and partial assemblage of sherds available for most pots recovered from the limited excavations at the site. This method also provided us with a unique opportunity to learn more about these vessels and each other's perspective as we discussed the objects and the digital methods used throughout the process.

My assumption at the beginning of this partnership was that the same techniques used for drawing archaeological pottery could be used to generate an estimate of an ancient vessel from Providence Bay. That data could then inform the creation of a rough, digital outline of a vessel form and complete 3D modelled pot. Pottery illustration is an excellent method for conveying detailed information about ceramics that would not be easily visible in a photograph (Collett 2012:3). Techniques to determine form and dimensions of vessels, and filling in gaps in a vessel profile from limited sherd assemblages, can be extrapolated into 3D space, something that digital methods have been working to achieve for some years (Rodríguez Miranda et al. 2017; Selden 2017; Senior and Birnie 1995; Zvietcovich et al. 2016).

I was most interested in using a standard rim diameter chart to collect any sherd measurements I could recover from the highly fragmented pieces of Algoma Lipnotch Vessel #97 that had been recovered by Conway (1987; 1988) during his limited excavations of Providence Bay. I hoped that these measurements would provide clear insight into the vessel's exterior profile, and that I would be able to use these measurements to inform initial digital modelling, especially since limited sherd data

would require me to speculate on some elements of the vessel form when I modelled a vessel exterior using a 3D modelling program.

Once I created a digital model of a pot, I would then be able to “test” it by integrating 3D scans of a limited number of sherds onto the model to create a printable composite. The process of blending analogue and digital methods intrigued me as it seemed to be an opportunity to demystify the process of 3D modelling somewhat by incorporating more widespread illustrative methods into this project. It also would allow me the means to estimate and model a pot despite the limitations of the highly fragmentary ceramics.

Following an autumn of working with the Providence Bay collections and taking measurements at the MOA, I went to the OCF to develop the first iteration of a Heart Pot model. The idea was that I would work and communicate quickly with Anong and other OCF staff as I progressed. The OCF therefore became a shared space for us to discuss the visualization of the Heart Pot and the heritage of vessel making.

#### **4.3: Collections and Initial Methodology Development**

It was important to select a suitable vessel that would be suitable for the goals of this project. I began my initial exploration of the collections at MOA by examining and photographing the range of ceramics previously designated to be vessels from Providence Bay. During that initial examination, I became aware of just how fragmentary the sherds were from this site and the limited number of sherds available for designated vessels. In many cases, I found that sherds were smaller than a quarter (i.e., 2-3 cm in diameter, see Figure 4.1) with rough broken edges.

In all, I found 12 out of 18 boxes of the Providence Bay collection included ceramics. Five of those boxes contained highly fragmentary body sherds that were too small and unattributed to a particular vessel to be utilized in this research. The remainder of the ceramic assemblage contained larger, mostly decorated ceramic sherds that had been separated out into distinct vessels during previous analysis. As noted in Chapter 2, Conway (1988) had identified 11 ceramic types, representing distinct material culture traditions. These designated vessels typically included mostly rims and decorated neck sherds, along with a limited number of body sherds assumed to be from that vessel. My impression of the collection and Conway's (1987) ceramic analysis is that individual vessels were defined primarily on the basis of rim form and decoration, while body sherds were ascribed based on similarities in fabric to those rim sherds, or because the body sherds were found in the same excavation context.

I was primarily interested in looking for vessels that Conway had identified as examples of "Algoma Ware," as he had presumed these vessels had been manufactured locally. Several vessels were given an Algoma ware classification with various additional style modifiers such as "Scalloped," referring to the rim's shape and decoration. One such vessel, made up of 40 sherds, was identified as "Algoma Lipnotch Vessel 97" (Conway 1988:119-22). This style is described as "knot or cord section punctates on the thickened outer edge of the otherwise plain lip. The neck is wiped smoothed, but vertical cord marks cover the body. The interior is plain" (Conway 1988:120). Conway's description of "punctates" appears to refer to a single row of left oblique tool impressions appearing just below the lip on the exterior rim of the vessel creating the "lipnotch" appearance (see Figure 4.2). While Conway had not commented

on the form of the vessel, I noted that the rim profile was slightly everted, while the neck was constricted, curved and short. Larger body sherds suggest a possible rounded body. Conway did not identify sherds specifically from the base of the vessel.

I was initially drawn to this vessel because the assemblage of sherds was more numerous, and some were larger than other vessel assemblages in the collection. Importantly for this project, the vessel also appeared to be smaller than many of the other vessels, which was an important criterion in determining which pot to work with since a larger vessel would have been a challenge to print.

There 40 sherds that made up this vessel were all contained in a single bag. Individual sherds tended to be irregular in shape, with roughly rounded outlines. The entire collection of sherds ranged in size from 9.8 mm to 71.1 mm in width, 7.7 mm to 50.4 mm in length, and 2.1 mm to 9.3 mm in thickness. To convey a sense of the range in size, 35% of the sherds were under 20 mm in length, 50% were between 20 mm and 30 mm in length, and 6% were over 30 mm in length.

Seven rims were present in the bag, five of which had been mended into two larger sections, joined using what appeared to be white school glue. Counting joined sherds as one, there were four rims in the assemblage for this vessel. The intact length of lip for each rim was: 65.3 mm (3 sherds) and 72.0 mm (2 sherds) for the two mended rim sections, and 29.0 mm and 29.4 mm for the two other rim sherds. There was a total of 195.7 mm of rim circumference available to estimate rim orifice diameter, which, based on my calculations below, represents approximately 40-42% of the complete orifice circumference for this pot.



As Conway noted, the upper rim below the lip was decorated with a single row of oblique impressions. The impressions are short and begin at the lip, angling obliquely down toward the body of the vessel. These impressions created the distinctive lipnotch that Conway stated characterized this rim type. Tool impressions were regularly placed, an average of every 4.7 mm along the rim, and were an average of 6.9 mm in length and 1.3 mm deep (Figure 4.3). The surface of the lip was flat and plain. The largest rim section of the vessel extended down from the lip about 31 mm in length and encompassed the rim and a section of the neck (Rim Section 1, see Figure 4.3). The body featured vertical or oblique cord marking (Figure 4.4).

Due to the fragmentary nature of the assemblage, it was difficult to determine the full length of the neck or the transition from the neck to the body of the pot. Likewise, while the few body sherds that were large enough suggested a round body, I could not identify sherds from the base of the pot, though variable thickness among body sherds present did suggest the base may have thickened lower down the body.

Overall, I did feel there were enough sherds present from “ALN Vessel 97” to become the focus of this project. However, in choosing this vessel, I also realized that my initial hope that the available sherds would be able to provide me with enough data to inform the modelling process had been optimistic. Instead, I needed to consider ways I could at least get some measurements from the larger sherds that could generally guide insight into the vessel profile.

For the purposes of this project I decided that I would only utilize sherds that were large enough to allow me to measure 30 mm in a horizontal or vertical direction that could inform my understanding of the curvature of the vessel (i.e., along the curve

of the sherd). In the case of rims, where a finished lip was a clear indication of the circumference of the pot orifice, I felt confident that these measurements would provide me with an accurate upper rim diameter of the vessel. In addition, I measured the rim sections' exterior curve every 10 mm below the lip, to continue to document the exterior diameter of the vessel. Similarly, I measured curvature of the one body sherd large enough for this study (Body Sherd 1). Doing so provided me with some sense of vessel shape along the body of the vessel.

Ultimately, I could only use the two mended rim sections and one large body sherd for measurements (Figure 4.5; see Table 4.1). The two other rim sherds available, I felt, were too small to offer additional measurements that were not obtainable from the larger rim sections. While a second body sherd (Body Sherd 2; see Figure 4.6) was large enough, I suspected it might have been incorrectly attributed to Vessel #97 because the colour and fabric of the clay was inconsistent with the other sherds assigned to this vessel. Additionally, two additional body sherds that were close to the criteria I had set were much more difficult to determine their orientation (Figure 4.6). I did keep out the other two rims and three to four body sherds in case they could contribute in the future to clarifying vessel shape.

**Table 4.1**  
**Measurements of Sherd Specimens Used to Record Curvature (in mm)**

Sherd	Length	Width
Rim Sherd 1	72.0	52.1
Rim Sherd 2	65.3	31.6
Body Sherd A	30.1	46.3

#### 4.4: Estimating Providence Bay Vessel Dimensions and Shape

A large volume of ceramic reconstruction literature focuses on the use of vessel profiles to trace the silhouette and graphically illustrate the shape of a vessel. However, this manner of modelling vessel shape can only be done when there is a complete profile from lip through body present, made up of individual sherds, or with an intact vessel section. As the sherds in the Providence Bay collection were all highly fragmentary and clearly represented only a portion of each identified vessel, a profile could not be directly reconstructed. While archaeologists can interpret or imagine vessel shape from such highly fragmentary sherds, a representation of the heritage craft of pottery making needed visual support to illustrate that interpretation for the OCF and its patrons. I needed to recover what I could from these sherds to inform subsequent digital modelling of this vessel's form.

Rim diameter charts (Figure 4.7) are useful when working with incomplete ceramics as they provide a means of measuring the circumference of, in particular, the upper rim or orifice of a pot. This technique has long been used in archaeology for estimating vessel orifice diameter from fragmentary rims (Collett 2012:4–7; Rice 2015:238; Hunt 2016:220). These charts are typically used by holding a rim sherd on the chart to match the sherd curve to the corresponding curve on the chart.

My first estimates of vessel shape began by measuring vessel orifice diameter from the curvature of the lip of the two rim sections I had for Vessel #97 by placing each rim section upside down on the chart where it aligned with a curvature increment. In determining how to record rim sections, I decided to record curvature along the vessel's

exterior since I would be digitally modelling the vessel from the outside inwards. Sherd thickness would then inform the internal dimensions of the vessel.

My sense was also that this chart could be useful for estimating shape and diameter below the lip of the pot, and in this way, start to fill in the gaps in the rim and vessel profile. So, I used the rim diameter chart to record exterior curvature as a series of bands recorded every 10 mm along the length of the sherds I examined. Based on previous archaeological work at the site and for the region at this time period (e.g., Conway 1987, 1988; Fox 1990), I was working with an assumption that the pots from Providence Bay would have been symmetrical along a central vertical axis. This symmetry meant that vessel shape could be represented by determining change in diameter along concentric bands since these measurements would roughly be fixed around the vertical axis of the pot (see Figure 4.8). In effect, I would recover a series of measured, circular bands that could be stacked together to give me a sense of vessel form, at least for those sections represented by the sherds I had to work with from the assemblage.

But to record exterior curvature on the pot diameter chart, I would need to generate a proxy, in order to avoid eyeballing estimates. I decided to use modelling clay to capture the external curvature of a 10 mm thick band from the lip down. To accomplish this, I cut small sections of modelling clay into strips. I then put the sherds I measured into plastic bags to ensure no modelling clay would adhere to or damage the sherds. I then pressed the clay onto the sherd at the appropriate band. Care had to be taken when removing the modelling clay from the plastic so as not to alter the curve captured in forming the clay. I then placed the modelling clay on the rim diameter chart

to record curvature (see Figure 4.9; note that in the figure, a modern ceramic cup is used to illustrate recording exterior curvature).

I began taking measurements with the rim sherds (Rim Section 1, which consists of two sherds, and Rim Section 2, which consists of three sherds). Rims were the obvious place to start, as their lips have a finished edge at the top of the vessel, making it easy to place onto the chart and determine curvature and estimate diameter. It is also straightforward and obvious to determine where the rim's position is on the vessel, much like the edge pieces of a puzzle.

**Table 4.2**  
**Band Measurements for Each Sherd**  
**(measurements in mm)**

Sherd	Band Location	Curvature Score	Estimated Pot Diameter	Sherd Thickness
Rim 1	Band 1 Lip	7.5	150	5.7
	Band 2 (0-10mm)	7.0	140	6.2
	Band 3 (10-20 mm)	7.5	150	5.9
	Band 4 (20-30.5mm)	8.0	160	6.2
Rim 2	Band 1 Lip	7.0	140	6.4
	Band 2 (0-10mm)	6.5	130	6.5
	Band 3 (10-20 mm)	7.0	140	6.3
	Band 4 (20-30 mm)	7.5	150	6.1
Body A	Band 1 (0-10mm)	9.5	190	5.2
	Band 2 (10-20 mm)	11.0	220	6.0
	Band 3 (20-30 mm)	11.5	230	7.5
	Band 4 (30-40 mm)	12.0	240	8.6
	Band 5 (40-42.3 mm); longest length of the sherd by orientation	12.0	240	8.7

The other sherd used to record vessel curvature was Body Sherd 1. This sherd proved to be challenging to orient for measurement. I decided that, because the sherd became thicker towards one end, the orientation should align so that the sherd's thicker

part was lower along the body. Once oriented this way, I then measured the sherd using the same method used for the rim sections.

Using the diameter chart provided me with an estimate of vessel diameter along a series of bands measured every 10 mm down from the rim for the first 30 mm of the vessel and provided me with estimates of diameter along a length of the pot's body at an unknown point below the neck. The measurements were gathered by aligning the sherd or modelling clay with a particular curvature on the chart. As the diameter chart I used provided me with the radius at each curve, the diameter was simply calculated by doubling the radius.

Measuring the two rim sections offered clear insights into the upper form of the vessel. As detailed in Table 4.2, the orifice exterior diameter for Rim Section 1, based on the lip's curvature, is 150 mm. Below the lip, the curvature of Band 2 reflects the narrowing or contraction in vessel diameter to 140 mm, a feature of the vessel's form that is also evident in the profile (Figure 4.10, 4.11). This upper rim form resulted in the potter giving the vessel both a curved neck and a slightly everted rim. However, that contraction is brief, and by Band 3 the diameter of the vessel is the same as recorded for the lip diameter, while by Band 4 the vessel diameter expands to 160 mm.

Rim Section 2 exhibited the same shape, though the curvature varied slightly from Rim Section 1, creating a consistent 10 mm difference in diameter estimates. This variation could suggest the two rim sections are from two distinct but very similar pots on the site. However, I suspect Conway assumed, and I would agree, that this variation likely reflects the fact that handmade ceramics feature minor inconsistencies across the vessel due to the process of their manufacture. It may also suggest that these two rim

sections were not adjacent to each other along the top of the pot. More importantly, the variation was slight enough to have a consistent insight into this pot's upper form to inform digital modelling.

Body Sherd 1 reflected a wider diameter than the rim sections. Diameter estimates ranged from 190 mm for Band 1 to 240 mm for Band 5. At Band 5, the pot's diameter is up to 100 mm larger than that recorded for the orifice diameter. The bands for this body sherd consistently increase in diameter as the vessel wall thickens through the sherd. While it is impossible to determine precisely where the sherd came from the pot's body, I could determine it was at least some distance below the neck since there was no evidence of any smoothed neck surface on the sherd.

I measured sherd thickness with callipers at the 10 mm vertical intervals, which is typical for pottery illustration (Collett 2012:9). I measured thickness from the side of the sherd. Thickness varied between two rims. But both rims were consistent in showing a slight thickening of the upper rim below the lip, presumably caused by both the finishing of the clay fabric at the lip and thickening caused by the row of decorative impressions applied there. Down on the body, the thickest point of Body Sherd 1, at 8.7 mm, suggests there was a general thickening of the vessel's wall lower down the pot. Given that the thickest body sherd for the entire assemblage for Vessel #97 was 9.3 mm (recorded on Body Sherd 2), this suggests the lower end of Body Sherd A was approaching the thickest part of the pot, which may have been near the base of the pot. The range in vessel wall thickness from lip to body provides me with a general sense of wall thickness variation, which I could then incorporate into the digital modelling.

The incomplete nature of this assemblage meant that it was impossible to fully document variation in the pot's physical dimensions or the overall form of the pot 30 mm below the lip. I did also have 40 mm of body shape but could not determine where on the vessel it fit or how it related to the two rim sections. In effect, beyond 70 mm of vessel form, I really could not rely on the bag of sherds in the Providence Bay collection to say more about the potter's intent in forming this pot. For example, the curvature of all the body sherds I examined for Vessel #97 suggests its body was less squat and more somewhere between elongated to globular in shape. But, on its own, having that sense of the body's general shape could not help me estimate other dimensions of the pot, notably an overall height.

The limitations and gaps in what I knew about the pot also would not be sufficient to meet the needs of the OCF for this project. To be able to begin to digitally model a pot, I would have to reach beyond the limitations of the 40 sherd assemblage for Vessel #97 to come up with an initial, overall representation of the vessel profile. Knowing the form would allow the digital modelling to represent and speak to the craft of pottery making rather than the archaeology of fragmentary ceramic objects. To get some sense of how best to bridge this gap, I reviewed available archaeological literature describing ceramic vessels recovered or reconstructed from late sixteenth- to early seventeenth-century sites in the north half of the Lake Huron basin (e.g., Fitting 1975; Fox 1990; Mason 1981; Ramsden 1990).

The archaeology of ceramic vessel forms from this region reflects the diversity of ceramic traditions archaeologists have documented, as discussed in Chapter 2 (Mason 1981). Local traditions reflect at least some influences being derived from ceramic



trends seen among more southerly Huron-Wendat sites, which is perhaps not a surprise given the identified Anishinaabe ceramic vessels that also have been noted on those same sites (e.g., Fox 1990; 2013; Ramsden 1990). Overall, while there is certainly variation in the range of vessels documented, pots from this region and time tend to exhibit a curved base below a round to squat body form. Necks are short and tapered or curved. Rims tend to be straight, everted or out-flaring, and finished with a flat lip that sometimes can feature one or more castellations. Many of these pots feature a formal collar defining the rim, which appears as a thickened clay band immediately below the lip and featuring decoration.

The diversity of pot forms and various vessel elements I noted during my review made it a challenge to bridge the gap of what I did not know about the shape and size of Vessel #97. But some elements of that vessel, such as the limited decoration applied to the upper rim, a single oblique row of tool impressions, as well as a short, curved neck, all suggested that some of the typical elements found within Huron-Wendat potter traditions at this time were part of the repertoire of the potter who made Vessel #97. For example, though distinct in size and rim forming, Fox (1990:461, 466) illustrates two vessels from Dunk's Bay, near the tip of the Bruce Peninsula, that exhibit some similarities with the decorative elements seen on Vessel #97. Fox suggested that these pots, both found whole, reflect ceramic types known from Wendat archaeological sites, referred to as "Sidey Notched" (Fox 1990:466; see MacNeish 1952 for the type description). These pots exhibit a single row of oblique tool impressions on a narrow collar by the lip of the pot. Below that collar, the vessels have minimal additional decoration, smoothed necks, and what appears to be smoothed or cord roughened

bodies. The form of the neck is relatively short and constricted, and the bodies are squat to round.

To be clear, I do not think these vessels are the same as Vessel #97. The size of the pots differs substantially, while the Providence Bay specimen lacks a formal collar for a rim, has a less constricted neck, and a cord-marked body. But I kept thinking about the fact that local potters at Providence Bay were clearly engaging with and interpreting a broad range of ceramic styles from across the Lake Huron basin in their pot making. And in making pots at Providence Bay, the assemblage from the site (Conway 1987, 1988) suggests local potters were incorporating stylistic elements seen elsewhere (or very nearby, as would have been the case for Dunk's Bay). So, while a formal collar is not present on Vessel #97, it does exhibit a slight thickening below the lip and is decorated by a single row of oblique impressions. The neck was smoothed, though neck contraction was less pronounced than seen for the Dunk's Bay vessels. The angle of expansion going down the neck on Vessel #97 suggests the demarcation between it and the shoulder was less marked than the Dunk's Bay pots (i.e., less curved). This angle to Vessel #97's neck, in comparison to the Dunk's Bay pots, also made me think its body, though round, was perhaps not quite as squat as the Dunk's Bay pots. Thinking through the differences between these vessels helped me imagine more clearly the likely possibilities for the elements missing for Vessel #97.

This bridging exercise suggested that Vessel #97 could well represent a local potter's effort to reimagine and form a pot along the lines of a style that would have been very fairly common from immediately south of Manitoulin Island during the potter's time making pots at Providence Bay. And so, in place of a direct, complete vessel form

that could serve as a proxy from Providence Bay or elsewhere, the Dunk's Bay pots at least offered me a means to imagine missing elements of Vessel #97. Doing so, in turn, helped inform the complete vessel profile I needed to envision to inform the digital model.

I recognize that much of this imagining is speculative. However, due to the highly fragmentary nature of the ceramics available, I faced a very large interpretive gap that had to be bridged. My goal after all was not to simply reconstruct the archaeological remains of sherds but instead find a way to shrink the gap we had to cross when making these interpretations. The archaeological data from Providence Bay was the jumping-off point to start the discussion with my partners at the OCF to deliver a digitally modelled and printed representation of Anishinaabe material heritage.

In the end, the deductions I made helped inform my estimation of a pot profile for Vessel #97 (Figure 4.11). That estimation incorporated both what I could learn from Providence Bay ceramic sherds and what I could imagine from the material heritage of pot making in the upper Lake Huron basin in the late sixteenth- early seventeenth-centuries. I translated the assumptions I made from general ceramic trends into this scaled profile, knowing that Vessel #97 had an orifice between 140-150 mm and a maximum diameter of 240-250 mm. My profile assumed those measurements could be aligned to then "fill in the blanks" of the pot down to a rounded base, especially if I made some limited assumptions about the pot being relatively symmetrical (see the next section for further discussion). Illustrating a speculative but complete profile informed by my limited measurements and assumptions about pot forms from this time and place ultimately helped me imagine and bridge what I did not know about Vessel #97. This

included arriving at a maximum possible height for the pot of between 220 and 240mm, as deduced from the profile I drew, and the known dimension of the upper rim (Figure 4.11). This speculative illustration of a pot profile I was able to bring with me to Manitoulin Island to share with the OCF. This profile also served as the backbone for the first model I would develop.

#### **4.5: Exploration of Software**

Once I created initial measurements and an estimation of vessel shape from the limited Providence Bay sherds available in the collection for “Algoma Lipnotch Vessel 97,” the next step was to create an initial digital model based on that estimation. As a result, I needed to explore software options to create a Heart Shaped pot.

In the case of this project, I was aware of several modelling or CAD programs such as AutoCAD that could have worked, and I had some previous experience with a range of digital imaging software like Maya and 3D Studio Max that might have been useful. While these programs would have led to the creation of a digital pot, I felt it was important to develop a relatively accessible and inexpensive methodology that would be viable for others to follow in the future. To me, this aim meant the Aahnkesjihgeh method needed to use an open-access rather than a proprietary 3D modelling program. Finding a quality open access program would mean there would be no costs associated with completing the digital model beyond ensuring hardware specifications were met, and the software would be available in the future.

Most of my research and modelling experience suggested that the program Blender (2019), an open-access 3D creation suite with an extremely robust collection of

tools (<https://www.blender.org/>), would be ideal for this project. Versions 2.78c, 2.79a and 2.8 were all utilized through the duration of this project. Blender is downloaded and run on the user's computer. This software's recommended specifications mean that it can be run on any computer with a 32-bit dual-core processor (2Ghz), with as little as 4GB of RAM (and 1GB of VRAM). In other words, an inexpensive laptop or desktop can run the software. 3D Studio Max, on the other hand, requires a processor that is twice as powerful, and the software specifications recommend having double the RAM (Autodesk 2020).

I had not previously worked with Blender as it was not a program that had been part of the standard workflow at the MOA, which meant I would need to teach myself how to use it. Doing so would also allow me to detail the process for the OCF and generate a thorough guide (see Appendix B). Blender is a popular 3D modelling program that is known for its ease of use. As an open-access program, it has a large and active community of users that regularly participate in forums. Blender also provides free tutorials for beginners (<https://www.blender.org/support/tutorials/>).

A workflow developed in Blender also offered several practical benefits. Users can adapt their work to the complexity of the desired detail level required for their project. In particular, for this project, Blender works well for both rough modelling and more complex and refined work required to finish a 3D model. As a result, it is useful for all stages of the modelling process, reducing the number of software programs I would be required to master. These features made Blender the far more appealing choice for me, for this project, and for defining a method that could be followed in the future.

A critical assumption I relied on to inform building the initial pot model in Blender was that ceramic vessel forms tend to be relatively round (see Figure 4.12). This assumption allowed me to further assume that horizontal “slices” taken from a model of the pot would generate a circle in plan view. The diameter for each “slice” would be based on the diameter estimated for the pot at that point along the vertical profile I had developed previously. This horizontal, or planar, circular symmetry is commonly seen in round-bodied ceramics. Additionally, ceramic vessels also reflect a mirror of reflection symmetry in profile. This form of symmetry means that the shape, when sliced vertically along its central axis, creates two halves that are mirror images of each other. It is for this reason that ceramic vessel forms are conventionally represented by a single profile (Mansouri and Ebrahimnezhad 2016:8352; Weyl 2017:52).

That these symmetries are a common characteristic of ceramic vessels made it possible for me to further my assumptions about the vessel's complete shape and bridge what I did not know about the pot beyond the limited sherds available.

I should note that, despite assuming the vessel had a rounded, curved form, to build an iteration of an entire pot, I would need to do so from within Blender’s modelling application rather than from its sculpting application as I could not be as precise when sculpting. Modelling would allow me to generate a form within a real-world scale, i.e., the actual and estimated measurements I had generated from Vessel #97. But in doing so, I would have to work with an object that had flat faces (sides) rather than a smoothed surface like an actual pot. I could have used the sculpting feature in Blender, which allows users to use digital “brushes” to manipulate the mesh surface in the same manner as manipulating clay in the real world. However, this process is much more

labour intensive and is not well suited to precision work, making it impossible to adjust across the vessel at a millimetre level consistently. To compensate for the modelling application limitations, I intended to develop a final model of the pot with a very large number of vertices and faces per horizontal layer. Doing so would ensure the model, especially printed, would appear smooth.

To build my model in Blender, I intended to create the form by building up a digital version of the 10 mm “bands” I recorded along the actual sherd, from the bottom to the top of the pot. This approach would allow me to begin at the base of the pot, estimating a “diameter” for the vessel's bottom-most layer. Subsequent layers would then be added to that first layer by “extruding” them from the layer below. I expected to rely heavily on the extrude tool in Blender to initially shape the model. Extrusion in Blender basically entails creating a new surface from a set of existing points on a model, allowing the user to extend that part of a model in a specific direction (see Figure 4.13). By extruding and then resizing new 10 mm layers repeatedly, much like stacking coins, I would be able to alter the shape and size of individual or groups of layers (e.g., altering diameter for one or more layers, or “coins”). Each of the new extruded layers I created would represent the next planar diameter added to the pot, collectively constructing the vessel form and profile.

I had previously tested this extrusion process using Autodesk’s 3D Studio Max to build 3D models of vessels based on images. The process of building an entire vessel using extruded layers proved to be much more challenging, however, since there were no images of unfragmented or reconstructed vessels to inform the modelling. So I had to rely on the real and estimated measurements I had generated from the limited sherds

I had to work with, in much the same way the process of ceramic illustration works from fragmentary sherds to create an estimation of a pot (Collett 2012; Hunt 2016).

## **4.6: Making, Consulting, and Revising the Heart Pot**

### **4.6.1 Building a First Model in Blender**

I started in “object mode” in Blender and selected a shape that would become the first “mesh” building block in my model. I chose a cylinder form to best allow me to craft and extrude pot layers to build up form since cylinders have circular bases. Each layer would be a thin cylinder resized to the pot's estimated diameter at that point along the pot form. During this initial modelling, each cylinder would be solid, and the final pot itself a solid object. Hollowing out the pot to measured wall thicknesses would be left to a subsequent stage of the modelling.

The first Blender model began as a cylinder with 32 faces/vertices (Figure 4.14A). Once selected, I switched to “edit mode” (Figure 4.14B), which places the object in scalable space and allows users to manipulate objects more freely (Note that in Figure 4.14B the grey grid behind the cylinder layer is 10 mm x 10 mm). In edit mode, I was able to resize the cylinder's height and diameter to form the base layer of the pot. This process can be seen in Figure 4.14, which depicts an arbitrary cylinder resized to mimic a band on a vessel. To create a rounded bottom, I began by creating a cylinder with a 10 mm diameter and then extruding several layers above, each having sharp increases in diameter.



For a 3D model that would eventually be printed, I realized that starting with an object with 36 vertices was a very low and rough count. A cylinder with 100 vertices, for example, would be much smoother. However, working with a high vertex count requires a much more substantial time investment to build as each layer would need to be smaller to create a smooth texture (see Figure 4.15). As I was only building a first draft of the model at this point and using an experimental method I had yet to confirm would work, I chose to focus on generating a rough first draft of the vessel form. Refinement and accounting for a final version and print would come later and after consultation with OCF staff.

Once I created the first layer, I began to extrude new cylinders up from the first layer to start modelling the base (see Figure 4.16). Using the ruled guide in Blender, I created layers whose diameters could be scaled to the vessel's size estimates for its position on the pot. I was less concerned with adhering to a uniform thickness for each band than I was with their diameters since some sections of the pot required a greater density of short layers to better create a smooth finish (e.g., at the base). Layers were created through a repetitive process of extruding and resizing up through the pot's body, neck and rim.

In the end, I arrived at a pot outline that approximated the estimated dimensions for the vessel I had developed previously (Figure 4.17). The first digital model created in Blender had the following dimensions: around 240 mm in height, 245 mm at its widest diameter, an orifice diameter of close to 160 mm, and a diameter of 150mm at the narrowest constriction of the neck. While these measurements were not exact, I did feel

the shape I came up with captured my assumptions arising from the sherd analysis, or at least enough to share this first effort with the OCF.

#### **4.6.2 Consulting on the First Model**

Discussing the first version of the pot I modelled with the OCF drove much of the logics informing subsequent revisions to that model. Those discussions tended to focus primarily on pots and pot making, and much less on archaeology or ceramic artifacts, beyond the general knowledge archaeology could provide on the nature of early seventeenth-century pottery making around the Lake Huron basin. Those discussions helped to shift the digital modelling towards the needs and priorities of the OCF. In doing so, the project became more about crafting an Indigenous digital heritage than advancing a digital archaeology.

Most of my discussions while I was at the OCF and around the first model were with Anong. Given her background as a ceramic artist and interest in the material heritage of the Providence Bay ceramics, it is not surprising that our discussions tended to focus on pottery and the craft of pottery making. These discussions also emphasized the fact that our understandings of the material heritage we were modelling came from different perspectives. For example, the terminology Anong and I used to describe pots was different. I referred to the shape of the Heart Pot as “globular,” while Anong referred to it as heart-shaped. What I called the “rim,” Anong called the “lip,” and what she called the “hip,” I called the shoulder. Anong’s language was reflective of the embodied nature of making pots, while my language reiterated archaeology’s classification terminology for ceramic sherds. While we became aware of these differences in the conceptual language we used, we still had detailed and technical conversations about ceramic

vessels and pottery making, taking us beyond the technical language and detail of the Providence Bay archaeological reports. Our lived experiences and differences facilitated our different expertise and our shared conception of the task at hand, which deeply informed and improved this project (Kay and Kempton 1984; Regier and Xu 2017).

The first model of a pot informed our discussion at the OCF about Providence Bay ceramic manufacture, which in turn helped us think about what was and was not right about the shape of the model. For example, since I did not know the true form of the vessel base, I reviewed with Anong what the archaeology I had consulted appeared to indicate, namely that rounded bases were a prominent feature of many pots in this time and region. I also noted the other forms present in the archaeological literature (e.g., Martelle 2004; Ramsden 1990), and that these variants were not typical and not reported from the northern Lake Huron basin.

In our discussions about what the archaeology could tell us, I was curious to know what my partners at the OCF thought of this reasoning. Anong generally concurred that the base of the model I had made looked consistent with the collections she was familiar with at the OCF, and she agreed that rounded pots would have been more common. But our discussion also extended beyond the archaeology of vessel form and into considerations of function. Anong noted in particular that rounded bases would have been easier to set down on the ground and balance them, as they could be pressed into the earth.

In effect, the first digital iteration of the Heart Pot focussed our conversation more on the general form and use of this pot within daily life at Providence Bay, than about

artifacts or digital modelling. I explained to Anong the choices I had made in Blender, especially that the first model was made using a limited number of vertices, which was why the model lacks smoothness. Anong confirmed her expectation that the printed model would need to be smoother to provide a better tactile experience for the people handling the pot. We agreed that the second model should enhance the pot's form and provide greater detail. To meet that expectation, I began a second draft with 100 vertices (See Figure 4.18).

#### **4.6.3 Revising the Heart Pot Model**

As my discussions with the OCF confirmed that the general form of the first model of the Heart Pot was meeting our expectations for vessels from Providence Bay, I knew I could develop subsequent iterations from that form. Blender allows users to import images into the program and position them in the scene (the space in which the user builds the model) to be used much like a reference photo in illustration work. The image is positioned in the background and is used to assist in the modelling process. So, I created a silhouette of the initial model and created a second model in the same form and size as the original, following that silhouette as a guide (Figure 4.19). Creating a second model using a cylinder with 100 vertices then consisted of importing the object the scene while in editing mode, sizing it into the first layer at the base of the pot, and then extruding layers vertically (Figure 4.20). I was then able to adjust the height and diameter of individual layers to align with the silhouette, and more generally, align the emerging pot shape with the original model's profile.

#### 4.6.4 Wall thickness and Hollowing Out the Heart Pot

With the guide of the first model's silhouette, I finished the second iteration quickly, despite being done at 100 vertices. That then set the stage for hollowing out the inside of the vessel, since at this point in the process, the digital version of the Heart Pot was a solid model in Blender.

In order to create internal space within the vessel – and in so doing, create vessel walls – I needed to work from the rim and extrude layers in the opposite direction towards the base by creating layers with a smaller diameter than those used for the exterior dimensions (Figure 4.21). This process results in a model where each vessel layer consists of two distinct layers, one representing the vessel's exterior dimensions and the other the interior dimensions.

I relied on the thickness measurements I had taken from the ceramic sherds as a point of reference to get the model as close to those recorded thicknesses as possible. To stay relatively close to sherd thickness measurements, a number of ruled guides in Blender can be adjusted to suit the scale of work being done. For this task, I set the grid to a millimetre scale so that I could confirm how much of the model interior I had to remove to create a vessel wall close to sherd thickness measurements. I progressed downwards from the vessel's lip, band by band.

I encountered two challenges creating wall thickness in this iteration of the Heart Pot. First, my measurements for Vessel #97 suggested that wall thickness was variable across the vessel and even across the body of the vessel. Across recorded sherds and along the Rim Sections and Body Sherd used earlier, this variation was relatively minor,

ranging between one to three millimetres. Trying to capture such minor variation would have been difficult to incorporate into individual Blender layers accurately, even if I had complete measurements for the vessel. So instead, I averaged sherd thickness, trying to estimate variation at differing points along the vessel's profile.

Second, as I noted previously, the vessel sherd assemblage did not include sherds from every portion of the vessel profile. As such, I had to estimate thickness for each of the neck, shoulder, body, and base, keeping in mind the variation I noted in sherd thickness. Doing so was easier working from sherd thickness averages across the vessel profile, than within and between adjacent layers. Given these limitations, the thicknesses I decided on for this iteration of the model served more as a placeholder than the final determination.

To hollow out the inside of the pot, I began by creating a second circle of vertices for the rim set at 5.6 mm thick, the average thickness of Rim Sections 1 and 2. Using the millimetre grid in Blender, I tracked that thickness in the model for each layer and adjusted thickness slightly to generally suggest walls got thicker toward the base, to align with the measurements taken from Body Sherd 1. The relatively consistent wall thickness for the Heart Pot can be seen in Figure 4.22. Figure 4.23 provides a side view of Body Sherd 1, while Table 4.3 provides the wall thickness measurements I recorded for this iteration of the model (see Figure 4.24 for a vessel model sliced to illustrate wall thickness).

**Table 4.3**  
**Heart Pot, Iteration 2, Wall Thickness Measurements**

<b>Thickness</b>	<b>Vertical Distance from Rim</b>
<b>5.3mm</b>	0mm
<b>5.5mm</b>	20mm
<b>5.9mm</b>	40mm
<b>6.0mm</b>	60mm
<b>7.1mm</b>	80mm
<b>9.4mm</b>	100mm
<b>9.0mm</b>	120mm
<b>8.7mm</b>	140mm
<b>9.3mm</b>	160mm
<b>9.5mm</b>	180mm
<b>11mm</b>	200mm
<b>11.2mm</b>	220mm
<b>8.2 mm</b>	240mm

#### **4.7 3D Scanning of Rim Sections and Body Sherd**

At this point in the process I had completed a second iteration of the Heart Pot model in Blender. The next task was to integrate 3D scans of Rim Section 1, 2, and Body Sherd 1 into the model, to both test and illustrate sherd placement on the model. To do that, I needed to generate digital 3D scans of the sherds, which could be imported into Blender and edited onto the Heart Pot model.

The six sherds I had previously selected for scanning were scanned using a handheld Artec Spider, which is a compact 3D scanner that captures and processes up to a million points per second, with a resolution of up to 102 microns, and an accuracy

of up to 51 microns<sup>3</sup>. The Spider projects a small light grid onto the object, and the points of this grid are tracked by two cameras, whose output is actively stitched together during the scan session to create a single model (Kersten et al. 2018:488–89). The cameras track the light projection on the surface of the subject to plot points in 3D space digitally. This process builds a “mesh,” which is the culmination of all vertices (corners), edges (sides of faces) and faces or polygons (surfaces of shapes) that exist in a model (Artec 3D 2016:23; Boardman 2013; Botsch 2010; Watkins 2012:7). The example in Figure 4.25 illustrates these individual elements that culminate to create a model’s mesh. The lines that crosscut the torus are edges, the points where those edges meet are vertices, the rectangles between the edges are faces, and the culmination of all of these elements is the mesh.

All scans were conducted at the Museum of Ontario Archaeology as the Providence Bay collections were stored there, and all necessary equipment was available (i.e., Artec Spider, turntables, laptop, support foam, etc.). 3D scanning at the MOA is in a dedicated space with lights, backdrops, turntables and various supports to hold objects while scanning. The Spider is connected to a Eurocom P750ZM laptop that has Artec Studio loaded on it (the proprietary software that controls the scanner), which allowed me to see in real-time the scans I was producing. At the beginning of this project, Artec Studio v.12 was used, however as the project continued, the software was updated several times, and so v. 15 was also utilized.

The Artec Spider scanner was designed to create high-quality models of small items with complex geometry, making it ideal for my purposes. Images of the scanning

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<sup>3</sup> <https://www.artec3d.com/portable-3d-scanners>



process using a non-culturally-affiliated object (a plastic elephant) have been included here to illustrate the process further.

Scans are done in sessions, meaning each individual capture of an object is a separate session. All sessions, once complete, are aligned and stitched together in the proprietary software (see Figure 4.26).

To create a scan that captures geometry from all sides of the object, the operator can use a turntable to slowly rotate the subject during the scan session. The model is not complete after this first session since one surface of the object is resting on the rotating turntable and thus obscured from the scanner. Subsequently, the object needs to be flipped during the second scan, so the missed portion can be captured (see Figure 4.27).

Following the completion of the two scan sessions, the user has two partial 3D models that need to be merged. In Artec Studio, merging is quite simple as points are selected to assist with the alignment process. The operator places points on parts of the scanned object that are visible within each of the partial scans (see Figure 4.28). The software uses these points to match parts of the models that align with one another, like magnets, and then makes any further adjustments needed to ensure the models fit well together. Following this alignment, an automated stitching feature is run to adjust the fit of the two models.

Aligned models are then “fused” together to create a final, single 3D model. This model can then be further edited and exported. Editing includes identifying and removing any noise still captured in the scan, such as small portions of the support

foam or turntable that get captured in the scanning process. These elements can create small objects around the model that need to be filtered out. This cleaning process is vital for creating a model that can be printed as it ensures the model mesh is solid (Figure 4.29).

When scanning the sherds from Vessel #97, I began by placing each sherd in a vertical position on the rotating turntable, supported with foam (Figure 4.30). The supports were taped to the foam base or secured with tack to ensure that the sherds would not move or become damaged. The supports used were neutral coloured, which allows them to be cropped out of each scan afterwards. Each sherd was scanned in two sessions, the first with the top of the vessel resting on the turntable, and the second after a 180-degree vertical rotation (Figure 4.31). I made sure that some portion of the sherd was visible for each scan to assist with the alignment of both scans when stitching them together subsequently. The scanning process of the two rim sections and body sherd took roughly six hours to complete.

It is often the case that noise and minor breaks in a mesh remain after aligning scan sessions, and that was the case for the sherds scanned here, as there were small errors left behind that Artec Studio is not well equipped to clean up. These errors include spikes, which are areas on the model where the mesh juts up sharply and is inconsistent with the object's topography (Figure 4.32). Other errors consist of small holes or gaps in the topography where too few points were captured to properly connect the mesh, or otherwise left openings in the mesh (Figure 4.33).

Correcting these errors consisted of importing the 3D models into Geomagic Studio 12, a 3D modelling suite used primarily to manipulate 3D models (3D Systems

2010). Geomagic provides a “Mesh Doctor” feature, which checks the mesh of 3D models for common errors and repairs them. This process can end up altering the model mesh so that it can lead to a slightly less faithful representation of the original object. However, this stage is essential if the intent is to print the model, since a broken mesh would corrupt the print. So, I was careful to review all corrections Mesh Doctor proposed for the three sherd models, to ensure those changes did not alter the form, edges, or surface topography of the scans (see figure 4.34 for a final image of the scanned sherds).

#### **4.8: Integrating Sherds into the Model**

At this point in the modelling process, I had been able to create a preliminary digital model of the Heart Pot that we felt was consistent with at least some of the seventeenth-century ceramic vessels that were made and used by the residents of the Providence Bay site. This model was constructed virtually but was informed by real-world metric observations I had recorded for these sherds, which then informed my more speculative estimations of vessel dimensions for missing portions of the vessel. Discussions with my partners at the OCF were instrumental in determining which assumptions we accepted and which we rejected to bridge the limitations of the fragmentary sherds available.

After the refined, hollowed-out iteration of the Heart Pot model was complete, and 3D scans of two rim sections and body sherd were finalized, the next stage in this process was to import the artifact scans into Blender and integrate them onto the Heart Pot. Integrating scanned sherds into the model would allow us to get a sense of how

accurate the Heart Pot form we had built was by seeing how well sherds aligned with the form, curvature, and thickness of the model. This exploration of sherd to model fittedness would help inform further alterations and inform my discussions with the OCF about printing and presenting the final form.

#### **4.8.1 The First Rough Merge**

The process of importing and integrating scanned sherds into Blender to be placed into the Heart Pot model was vital in the digital bridging process of transforming sherds to material heritage. In doing so, I was able to explore where these sherds might have come from on the pot by adjusting their placement along the model's exterior form and shape. This process was not meant to confirm the exact location of where these sherds originated on the pot since creating digital models in this manner was intended to be more an exercise in interpretation than one of restoration or reproduction.

I saved the 3D models of the sherds as .obj files, a standard 3D model format to encode an object's surface geometry. Blender allows users to import these files into an existing scene (Figure 4.35) using the import function. I copied the scan files into a separate folder to ensure that any alterations or errors that could arise from the merging process would not corrupt the original models. I then selected “file > import > .obj” and browsed individually for the files. Once imported, the models could be scaled to any size, dragged, turned, rotated and further manipulated in the scene.

Manipulating 3D objects in modelling software can be difficult since it requires the use of keyboard commands as well as the digital manipulation of the object by a mouse. In Blender, the centre mouse button rotates the scene around an object, while the R key

allows users to rotate on a specific axis. I found it quite easy to mix these two commands up and accidentally shift the entire scene. As a result, positioning the sherds onto the model proved to be a time-consuming process. Figure 4.36, for example, illustrates the small rotations and movements required at this stage. Even the sherd's slight movement from a raised position above the pot to make it completely flush with the model surface required several rotations and movements to ensure it was "correct.

I chose to only merge the sherds roughly with the model's body initially and did not worry about scaling the sherds in Blender to their proper size. Doing so allowed me to both familiarize myself with the process of manipulating the sherds and merging them. It also provided me with a sense of how well the placement of the sherds appeared (see Figure 4.37). By practicing merging the sherd models and coming up with a rough placement of those sherds on the pot, I could also share the resultant mock-up with the OCF. Using the mock-up as a point of discussion enabled me to review the challenges this step presented, while my partners could use this mock-up as a jumping-off point to prioritize better what they needed from the finished product.

Placing the sherds into the model revealed several issues between the model's shape and the shape of the sherds which had to be resolved before finalizing the composite model. For example, I was not sure where to place the body sherd, other than knowing one end of the sherd was thicker than the other end, and that the thinner end was thinner than the bottom of the rim sherds. Anong and I discussed the possibilities for orienting and placing this sherd and agreed that the thicker end should be the lowest part of the sherd down the body. In these discussions, our reasoning kept returning to the pot's practical intent: i.e., a thicker wall lower down the body would be

suitable for cooking and provide stability. But we also considered where to place the body sherd so that it presented well on the subsequent 3D print. In particular, it needed to be visible on the composite close to where the two rim sherds were placed since these three sherd models would convey vital information about the vessel. Given the sherd's thickness variation, I felt it could be placed close to the bottom of the neck on the vessel, rather than lower down the body, where it would not be as visible. So, we considered placing the sherd higher up the body. In the end, and as reflected in Figure 4.37, we agreed that positioning and orienting the sherd mid-way along the body was our best option since it presented well when on the same side of the pot as the two merged rims.

Additionally, while I had placed the rim sections close together on the model simply to illustrate how the merge would look when I talked to the OCF, doing so revealed how variable each of the rim sections were to each other (Figure 4.38). Notably, Rim Section 1 exhibited a relatively flat lip surface, while Rim Section 2 had a convex lip shape that could not be aligned with the model's flat lip surface. Additionally, Rim Section 1 had a much sharper curvature to its neck than Rim Section 2.

At the very least, the rough merge underscored that the rim sections likely were not close to one another on the original vessel. As previously noted in Section 4.4, this difference may be due to internal variation across the form of this hand-made vessel. Or this difference may suggest the two rim sections, despite Conway's assumptions, were not from the same vessel, even though they share similar attributes. When I reviewed these issues with OCF staff, we agreed there wasn't enough in the rims' variation to not proceed with merging both rim sections into the model. As well, while it may have been

more “accurate” to have shifted the placement of Rim Section 2 over to the other side of the pot from Rim Section 1, we decided against this option. Instead, we felt having the two rim sections close together made more sense for presenting the Heart Pot to OCF patrons. The two rim sections close together better conveyed visually the craft of pot forming. As well, it would underscore the notion that this model was an interpretation based on archaeological artifacts.

#### **4.8.2 Final Adjustments**

Following the rough merge and our discussion of that iteration of the model, I began the process of creating a final composite of the sherd models merged with the Heart Pot. First, I established a real-world scale for the sherds’ models within the Heart Pot Blender scene, as the final composite would need to reflect the real-world dimensions of the sherds. Scaling was done by opening the resize menu and setting each imported model’s scale to 1.0 for all axes. Working with 3D models of the sherds at real-world size was the first real bridge of digital and physical forms. Doing so meant I was now testing the assumptions we had made about the Heart Pot’s shape and dimensions from the limited sherds available for Vessel #97.

I used the previous experience that I had built up in the rough merge process to merge the now correctly scaled sherds into the model. I went through this process twice. The first merge allowed me to assess the model’s shape, thickness, and the resulting composite’s appearance. That merge also gave me insight into further refinements that were needed before the model was finalized. Following these additional refinements, the second merge would create the composite to be printed.

This two-step approach also allowed me to ensure the final and consequential decisions affecting the printed output were made in consultation with the OCF.

The merging process made it possible to see where the model did not align well with the sheds from Vessel #97. For example, merging rim sections with the model suggested that while they generally aligned well along the curve of the rim orifice, they did not align well with the neck of the vessel. This difference appeared to be due to differences in the curvature of the necks visible for each rim section.

I explored several ways to adjust the Heart Pot model, including shortening the height of all layers that made up the neck (see Figure 4.39). This measure still proved less than ideal because of the variation between the two rim sections. Basically, when neck layer diameters were widened to a point where Rim Section 1's neck curvature fit neatly in the model, Rim Section 2 would be partially buried within the model. But when the diameters of the vessel neck layers were narrowed to prioritize Rim Section 2, Rim Section 1 would jut away from the model, indicating the curve of the model's neck was not as wide and marked as Rim Section 1 required.

Given the direction the OCF had provided me with, I felt it was important to prioritize any final adjustments to ensure full visibility of both rim sections. So, I adjusted the height and diameter of the model's neck layers without changing wall thickness. I adjusted neck layer diameters so that Rim Section 2 was almost entirely visible but ensuring that the bottom edge and interior of Rim Section 1 was not fully exposing beyond the surface of the model (see for example Figure 4.39).



However, these adjustments had consequences further down the model. In particular, adjusting the neck layers created a sharp distinction between the neck and shoulder (Figure 4.39B), something that was not consistent with Providence Bay pot forms. I found myself further adjusting the lower neck and upper body of the model by expanding the diameter of layers to recapture the slighter curvature of earlier iterations of the Heart Pot. I did this by adjusting layer diameters 2 mm at a time and kept doing so until that layer had smoothly connected with the layers above and below. I retained the wall thickness that had previously been created for each layer when I adjusted diameters.

The cascade effect from this process of accommodating rim section curvature differences meant that I had to adjust all the pot body layers down to the pot's maximum diameter. Doing so effectively eliminated the sharply demarcated shoulder. It also meant the maximum diameter of the vessel model threatened to expand beyond the earlier estimates I had been working with from the vessel profile and early model of the Heart Pot. In the end, I was able to balance the curvature of the vessel's upper half while keeping the new maximum diameter to 245 mm. Vessel height and orifice diameter were not adjusted in this process.

Adjustments increased with every sherd merged with the model. In order to accommodate the body sherd, for example, I had to ensure that body wall thickness was adjusted along layers where the sherd was merged so it fit into the body wall. The decision to work with three separate models of sherds required a great deal of time to merge effectively by adjusting the vessel form. Ideally, I would have liked to have incorporated additional body sherds. But doing so would have required a much greater

time investment. A larger-scale merging of sherds felt, both to myself and to the OCF, to be a different and distinct undertaking.

There remains the possibility that the sherds I analyzed were not from the same vessel, despite Conway's classification. But even if the sherds are not from the same pot, the challenges I had to work through in obtaining a perfect alignment of the sherds' physical characteristics to the Blender model remained. Notably, as a hand made craft, the Providence Bay vessel likely would have encompassed slight variations in form. As suggested by the variable sherd thicknesses and the variation between rim sections, such subtle variation would have been difficult to capture in Blender as discrete variations within and between layers. The process I adopted to model the Heart Pot consisted of stacking perfect, concentric circles, represented as discrete layers and distinct diameters. Any inconsistencies that existed in Vessel #97 would have been challenging to map within these concentric circles. Also, in Blender, it would have been impossible to make these changes without sacrificing the goal of replicability by extruding new layers. For example, to slightly adjust vessel wall thickness at discrete locales along a single concentric layer, or aligned across several layers, would have involved a vast number of minor edits aligned not just within adjacent layers but across the whole model. While the OCF Aahnkesjihgeh method models objects using mesh, allowing users a high degree of control over the dimensions of the object they create, minor alterations must be done at the vertex level, moving each point (vertex, face, etc.) at a time. Such minor variation is possible to model within Blender's sculpting mode, but it would have meant control over scale would have been sacrificed.

My experience working through the different iterations of the Heart Pot and merging 3D models of the ceramic sherds with the Blender-generated model provided me with a greater appreciation of the challenges of digitally creating and interpreting archaeological objects as heritage (Figure 4.40). The modelling process I developed in Blender borrowed techniques from artifact illustration conventions. But it was the integration of sherds that forced me to interrogate our assumptions about the “correctness” of the Heart Pot, identify the key priorities for this project, and underscored that this digital archaeology project is less about reconstructing archaeological artifacts and more about representing material heritage from a fragmentary record.

A future build with the Aahnkesjihgeh method using more sherds and applying other techniques that might better accommodate shape and form variation across a pot would be worth pursuing. The Aahnkesjihgeh Method has proven to simultaneously illustrate archaeological information while going beyond the limits of that information. As a result, this method has allowed the OCF and I to explore and present the ancient material heritage of pottery making that took place at Providence Bay 400 years ago.

## **4.9: Print Preparation and 3D Printing**

### **4.9.1: Model Preparation**

The final stage of this project involved the 3D printing of the Heart Pot using the 3D Systems ProJet 660Pro printer at the Museum of Ontario Archaeology. As noted earlier, this is a powder and binder printer which builds objects by depositing layers of mineral powder that are held together with binding agents and ink and provides the

ability to print objects in colour, including an approximation of colour from the texture recorded for 3D scans. It functions similarly to most inkjet printers, depositing a single layer of powder at a time.<sup>4</sup> The ink and binder simultaneously build the object and deposit ink into the powder to colour the object's surface, leaving a distinctive “ring” pattern of layers slightly visible on the print's surface.

At the start of the project, our discussions about what the 3D print of the modelled pot should look like had not been too detailed beyond a general agreement that it should be a representation of a pot from Providence Bay, and that the OCF would use it in its programming. Questions about what pot surfaces should look like, or the colour of the print, only really took shape well into the digital development of the model.

For example, when we reviewed the rough composite iteration of the model and sherd scans, Anong and I discussed the possibility of extending the decoration seen on the sherd rims across the full extent of the model's rim. We also discussed the possibility of mirroring the cord marking visible on Body Sherd 1 across the model's full body. While I was sure this revision was possible, I quickly realized it would be a significant undertaking, requiring the introduction of an entirely different skillset to the process. In particular, the pot had been built in Blender's modelling mode since this allowed me to build models to scale and within a mesh. To extend decoration and body surfaces beyond the merged scans, I would have needed to switch to the digital sculpting mode. Digital sculpting these surface features of the pot would have involved altering the shape of pot surfaces in similar ways to manipulating clay in the real world.

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<sup>4</sup> <https://www.3dsystems.com/on-demand-manufacturing/colorjet-printing>

Specifically, I would have had to sculpt into the model each decorative impression myself using the sculpting tools in Blender. I would also have had to replicate cord-marked body surfaces by copying the sherd pattern and adjusting surface topography across the model. While the effort would have brought the printed pot closer to Anong's preference for a print that could provide a more tactile experience, undertaking those changes would have been a challenge to get right. It also would have significantly delayed completing the project.

As well, once I completed a final, refined digital composite of the Heart Pot, and the time to schedule the printing of the vessel had arrived, Anong had moved on from her position at the OCF. The staff I interacted with at that point shifted to Naomi Recollet and Sophie Corbiere, the two OCF staff that jointly took over the duties of the OCF's Executive Director. This change in the people I interacted with representing the OCF shifted the priorities of, in particular, what the printed version of the pot should achieve. For example, Naomi and Sophie were less focused on the pot's tactile qualities and more on its presentation qualities to serve immediate programming needs. This shift also meant the delay that would have been caused by extending decoration and body surface characteristics across the model was a concern. So, the OCF came to feel that it was not a step I needed to undertake for the project.

Initially, the OCF and I had talked about the final print being false coloured to avoid the model appearing too close to the original colour of the ceramic sherds. I first prepared a Heart Pot model for printing that featured the 3D scans of the ceramic sherds appearing as uncoloured (white) portions embedded within a pale blue model. A later model was made green, simply to distinguish it from the previous blue iteration.

However, when I presented the green model to Naomi and Sophie, they raised concerns about the colour. While they agreed that no one could mistake the green model for a real archaeological vessel, they also felt green was too jarringly different from the archaeology on Manitoulin Island. So, we discussed revising the colour to something that would more closely represent a ceramic vessel. We agreed, as well, that the integrated sherd scans would remain white so as to denote the difference between object scans and model representation.

In order to add colour to the model, I used a texture map from Rim Section 2 that I generated while scanning the sherd. A texture map is an image file that conveys a 3D object's surface details, including colour. Thus, this file was the best tool I had in hand to sample the colour from a sherd, especially since Rim Section 2 featured the majority of the colours present across the 40 sherds identified for Vessel #97. I then applied that colour to the model using the texture file, replacing the green, and left the 3D sherds uncoloured (Figure 4.41). This revision was reviewed with Naomi and Sophie, who felt the change to be much more appealing. This iteration of the model thus became the final iteration of the Heart Pot that would be printed.

#### **4.9.2 3D Printing the Heart Pot**

The 660 ProJet utilizes proprietary software in the process of printing a 3D model. I began by importing the Heart Pot as a polygon file (.ply) into 3D Edit Pro, which verifies that the model was suitable for printing. This program conducts a quality control review of the file, verifying that there are no holes in the mesh and that the texture on the model had been properly applied for printing purposes. Polygon files are one of the

most common file types used for working with 3D models in colour as they store both texture (colour data) and geometry in one file, as opposed to using a separate file like a texture map. Once that task was completed, the file was saved as a .zpr file compatible with the 3D printer. While polygon files are also compatible with printing, there had previously been print errors related to the presentation of colour when operating the 3D printer in my time working at the MOA, so I simply avoided the issue by working from a .zpr file.

The model is then imported into 3D Print Pro, which helps the user virtually “place” the 3D model within a digital representation of the printer’s bed to confirm size compatibility (Figure 4.42). This process, which is usually routine, became an issue when I went to print the Heart Pot. Specifically, when using “quick place” in 3D Print Pro, it became apparent that the model would not fit within the maximum dimensions of the print bed. Unfortunately, the maximum diameter of the model proved to be just beyond the print bed limits.

This realization occurred exactly at the point I would otherwise have hit “print” and completed the project for the OCF. As such, I phoned the OCF as I sat at the computer controlling the printer to review how to proceed. We had two options: scale the model down to fit the print bed or print it off in separate sections, adding join slots to the model so that they could be pieced together. Both of these decisions would impact the print. Handling a scaled-down model would be a different physical experience for patrons but handling the glued joins of the model parts would be a detraction.

In our discussion, the fact that the printed model would need to be handled figured prominently and that a segmented print could potentially be more fragile long term. As the OCF had plans to use this model in teaching contexts where many people would handle it, the decision was made to prioritize printing a model that would be structurally sound. Sophie acknowledged that while reducing the pot's size was not ideal, she didn't feel this would detract from the teachability of the pot since it was likely that there would have been other vessels at Providence Bay that were smaller than the Heart Pot.

Working from the dimensions of the print bed, I estimated the pot would need to be scaled down by 20% to be printed as one object. Reducing the pot's size that much would mean reducing the maximum diameter of the pot to 196 mm, while the height of the pot would be reduced to 194 mm. If this project had been a conventional digital archaeology project focussed on virtually making a pot from sherds, I would have felt the greater priority was to print the pot in sections to account for and stick to those archaeological estimates. Instead, the logistical workaround of scaling down the model, though taking the physical output past the careful measurements and estimations I had generated, also reaffirmed this project was primarily a collaboration. The work we undertook was a highly interpretive exploration of ceramic sherds from Providence Bay to explore the contemporary Anishinaabe heritage of pottery making on Manitoulin Island. The outcome of this collaboration needed to serve the OCF's priorities, especially those that continued after the project ended.

The final printed vessel (Figure 4.43, 4.44) was delivered to the OCF shortly before the beginning of the outbreak of the Covid-19 Pandemic. While I have been



unable to review with the OCF how they have incorporated the pot into their programming, I know they have the pot on display and that participants have been interacting with the pot as part of ceramic workshops.

Before seeing the pot, I had built up assumptions of what it would have felt like to hold it. I had spent so much time manipulating the model in 3D space, however, that the understanding I had of the vessel was purely cognitive. Being able to touch and see the model, I was struck by how different it seemed to the touch. The body's curve felt more dramatic than I had anticipated, and at first, I could not figure out where to put my hands to hold it most comfortably. After holding it for a moment, without thinking, I settled on holding it from the base (Figure 4.45).

The final print, while smaller than the original model, was still able to be handled in the ways that Anong was most interested in allowing learners to do so, which meant we had successfully accomplished one of our goals. The adoption of the ceramic colour for the model, as proposed by Naomi and Sophie, was much more effective at conveying the sense of the print being a representation of ceramic heritage, not archaeology. The colour of the model also helped highlight the uncoloured sherds, to convey both where archaeology informed and didn't inform, the final model. Learners and community members at the OCF now have a physical vessel that they can touch and interact with, giving them a sense of our current best guess of what an Anishinaabe pot, made in the early seventeenth-century from Providence Bay, would have been. The pot that they interact with is a physical manifestation of the digital process informed by the highly fragmentary and incomplete archaeological record. This process has offered

the OCF an opportunity to create new understandings of this craft in a way that would not have been possible otherwise.

## Chapter 5

### 5.1: Reflections on Third Wave Digital Archaeology

Digital archaeology offers us the unique opportunity to transform artifacts into heritage. In our case, we were able to leverage a range of digital archaeological technologies to take a fragmentary, partial artifact assemblage, previously inaccessible within archaeological classifications, terminologies and repository, and transform them into a material heritage in service of the community.

With the Heart Pot, it is now possible for community members to see and interact with our interpretation of a past craft. The sherds themselves were too small and fragile to have been handled the way the Heart Pot will be, but by creating a new material representation of that archaeology through collaboration, we enabled a new way of sharing Anishinaabe heritage. The OCF and I worked together to create the Heart Pot as one way the gaps in the archaeological record from Providence Bay could be bridged for community members and descendants visiting the OCF and Manitoulin Island today. This vessel is not a perfect reproduction, but instead represents the ancient Anishinaabe pottery-making tradition on Manitoulin Island that can be handled and shared at the Centre.

Digital archaeology offers a new future for archaeologists concerned with engagement and access by allowing community members to engage with their material heritage beyond the limitations of the record. Likewise, while archaeological research is the foundation for understanding temporal and material lifeways in context, this project provided the OCF a way to appreciate and promote Anishinaabe pasts beyond

archaeological interpretive conventions of culture history. Some researchers have argued that incorporating digital technologies into the discipline makes teaching easier and facilitates better learning (e.g., Averett, Counts, and Gordon 2017; Boast and Biehl 2011; Lock 2006). But we also need to be aware that these technologies do change our practice. The current “third wave” in digital archaeology is deeply concerned with how these novel methods we employ affect what we produce and learn (e.g., Huggett 2015; Perry and Taylor 2018). Over the course of my MA, I was able to observe two ways in which this assertion is accurate. First, the use of Blender provided us with a way to rapidly model both rough and smooth pots and second, collaboration informed our mutual understanding of the vessel and thus altered the shape of the Heart Pot.

As Huggett (2015:92) states, the digital tools we utilize do not always work well when we need to convey meaning that exists beyond the limited facts we use to build interpretations. In our case, we were working with minimal ceramic data but were able to generate a model that is immediately recognizable as an ancient pot. The challenge here is that the Heart Pot is not a specific pot, but instead a representation of the craft of pottery making. The original potter made their vessels by hand, actively deciding on the vessel's shape as they worked their clay. I instead took my cues from the shape and measurements of the sherds I had from the vessel. I then digitally modelled a vessel form that best fit what I had deduced from the ceramics themselves, from principles of symmetry, and from other vessels documented in the archaeological record. Doing so allowed me to fill in the gaps of what I did not know about Vessel #97. Had the whole vessel been available, we would have had a direct link to the potter. Instead, we were able to leverage a digital platform to tangibly represent our thoughts and interpretations

of what the output of ceramic manufacture could have looked like at Providence Bay. The work we do as digital archaeologists is interpretive and involves finding ways to fill in gaps from a time and place that we do not know or can internally understand. The leveraging of digital technologies, however, cannot combat this subjectivity alone. That work needs to come from us.

I would agree with Huggett that we need to be introspective in our use of digital technologies. In my partnership with the OCF, Blender was highly suited for the work we were doing building digital models with complex geometry. In Blender, it took a minimal amount of time to produce a simple 3D model that reflected the form of a pot, allowing me to build the first early models in a day. This build-time lent itself well to working collaboratively since I could produce more than one iteration of the Heart Pot while working with the OCF and implementing their feedback quickly into later versions. Blender was also user friendly, meaning this methodology could be used by other researchers and advance even more complex digital representations of the material heritage.

Collaboration brings another layer of introspection to not just digital archaeology but archaeology more broadly. Collaborative archaeology allows us to remedy some of the problematic ways that our practice has kept the heritage of Indigenous peoples as archaeologists' property, and in so doing, exclude Descendants from participating in the discourse (Colwell-Chanthaphonh 2012:267, 271-273). Atalay (2006) argues that the shift in practice towards a broader collaboration can be a part of decolonizing archaeology; turning control of heritage materials back into the hands of communities disrupts the current system that keeps heritage the sole domain of archaeologists.

3D modelling and printing can be an acceptable way to improve this access. However, it is not a replacement for proper engagement. Haukass and Hodgetts (2016:47-50) show that these methods need to be a part of the broader process of engagement and collaboration, not a replacement for it. My time working with the OCF on this project underscored this point. The delivery of the Heart Pot print to the Centre was not the sole aim of our work, but instead one outcome of a broader process of engaging deeply in collaboration to discover what could be meaningful about Providence Bay's archaeology for the community. Our collaboration allowed us to work with collections that the OCF had control of to facilitate an increased engagement with those collections and learn beyond the limits of a fragmentary ceramic record.

## **5.2: Limitations of this Research**

While Blender was vital to the work we undertook, there are also some important limitations to this method to be aware of when using it. Blender is relatively user-friendly, but it is still quite daunting for new users. The details of the OCF Aahnkesjihgeh method is laid out in Appendix B to assist others, but nonetheless, the process is difficult to troubleshoot, and some familiarity with the jargon of digital animation is vital in becoming familiar with the logic of the software workflow. Blender is also a program intended for the creation of artistic work, so this method is not a path to producing a perfect model from imperfect datasets.

As is the case with physical ceramic reconstructions of broken potsherds, when creating a 3D model of a vessel, I was not interpreting that form from all the pieces of the puzzle. Ideally, the greater the number of sherds in the collection and used to build the final composite vessel, the more representative it can be of the original. But at the

same time, I discovered that, with every additional sherd added to the composite, new issues and challenges in size, form, and curvature emerge, challenging the model I had created. Building the composite allowed me to see that the vessel's digital model was not a perfect canvas to place those sherds. This misalignment was due either to the original, hand-made pot not conforming to the perfect, concentric shape of stacked circles I had built up from layers of cylindrical disks or because the sherds themselves had not actually all originated from the same pot. The challenges this posed ultimately led to modifications in the form of the model. While the OCF Aahnkesjihgeh method is well suited to building an approximate silhouette of a highly fragmentary vessel in a short period of time, it is limited in being able to capture the nuances that would have existed across a hand-made pot or to second guess the classificatory assumptions and past sorting errors in the analysis of pottery sherds.

The Heart Pot is also limited in representing the vessel from Providence Bay since there were no sherds that could be readily recognized as coming from the vessel's base. Given the limitations caused by what was missing, the Heart Pot is only an approximation shaped by my interpretive estimations, which themselves were built from limited sherd measurements, assumptions of symmetry and knowledge of the archaeological record of pots from this time and region.

The Heart Pot print, in the end, is a physical manifestation of a digitally estimated and adjusted approximation of a vessel that we strived to be consistent with what we know about pottery making as it occurred at Providence Bay around 400 years ago. Archaeological constraints and limitations precluded knowing precisely the potter's craft and intent. Nonetheless, the Heart Pot represents an invitation to think about the

Anishinaabe artisans and their ceramic-making tradition as they practiced it on Manitoulin Island in the early seventeenth-century.

### **5.3: Future Research**

Collaboration does not end with the last official day of a project, as has been proven right for this collaboration. The research and writing phases of my MA are complete, but I have continued discussions with the OCF regarding the future of our work. Previously, we had planned to meet with community Elders to share what we had learned from the process and unite the sherds of Vessel #97 with the print at the OCF. Due to the pandemic, I was unable to make the trip. When possible, I will return to Manitoulin Island and join with the OCF to present our project to the Elders. The combination of working with the original ceramics and the Heart Pot we hope will create a rich learning experience for those in the community who want to know more about the Anishinaabe ceramic-making tradition of Manitoulin Island.

As the focus of this thesis was relatively narrow, we could not explore some of the questions the OCF had about the heritage of Anishinaabe pottery manufacture. To understand these traditional methods, we would need a comprehensive study of the various vessel forms present on Manitoulin Island through time and identify clues to changes in their manufacture. While this was something that the OCF had a strong interest in learning more about, this is an entirely separate project inviting a physical examination of the different physical characteristics of ceramics, combined with digital techniques such as micro CT scanning. This work would assist the OCF's aim of bringing us closer to understanding the past practices of potters at Providence Bay, Manitoulin Island, and along the north shore of Lake Huron.



The OCF Aahnkesjihgeh method, as currently written, is intended to assist those hoping to build round pots. However, it is not well suited to modelling more complex objects. Artifacts such as smoking pipes would be difficult for a new user to conceptualize through modelling, and nearly impossible to execute without a substantial time investment or the ability to 3D scan complete specimens. We hope that the strength of the OCF Aahnkesjihgeh method for new users will be the explicit direction I have provided to meet a specific task. A second iteration of this methodology would be beneficial for a broader range of modelling tasks from fragmentary artifacts.

#### **5.4: Concluding Thoughts**

Throughout my partnership with the OCF I was able to see the effects of collaboration in archaeology. Previous work at Providence Bay did not engage with the community and was also not broadly known in the community. Anong and I were put in contact as we were both seeking to do something that was different from what had come before. The approach we took is consistent with what McNiven (2005:237) states collaboration with Indigenous communities should look like: initiated by the community and equitable. Archaeologists should be working together with Descendant communities as equal partners to make the archaeological record more accessible to those seeking to interact with their heritage. We should be making our roles as the investigators and keepers of heritage and knowledge obsolete. Instead, we should be moving towards braiding the perspectives and knowledge of communities and adopting research methods to assist communities with their goals, not ours.

Throughout our partnership, I was able to see how our work was meaningful to the community. Despite the end of this project and research, I am hopeful that this will

not be the end of my partnership with the OCF. I still hope to advance the OCF Aahnkesjihgeh method and find other novel ways that my skillset can facilitate even more access to their material heritage and share our research and findings with community members.

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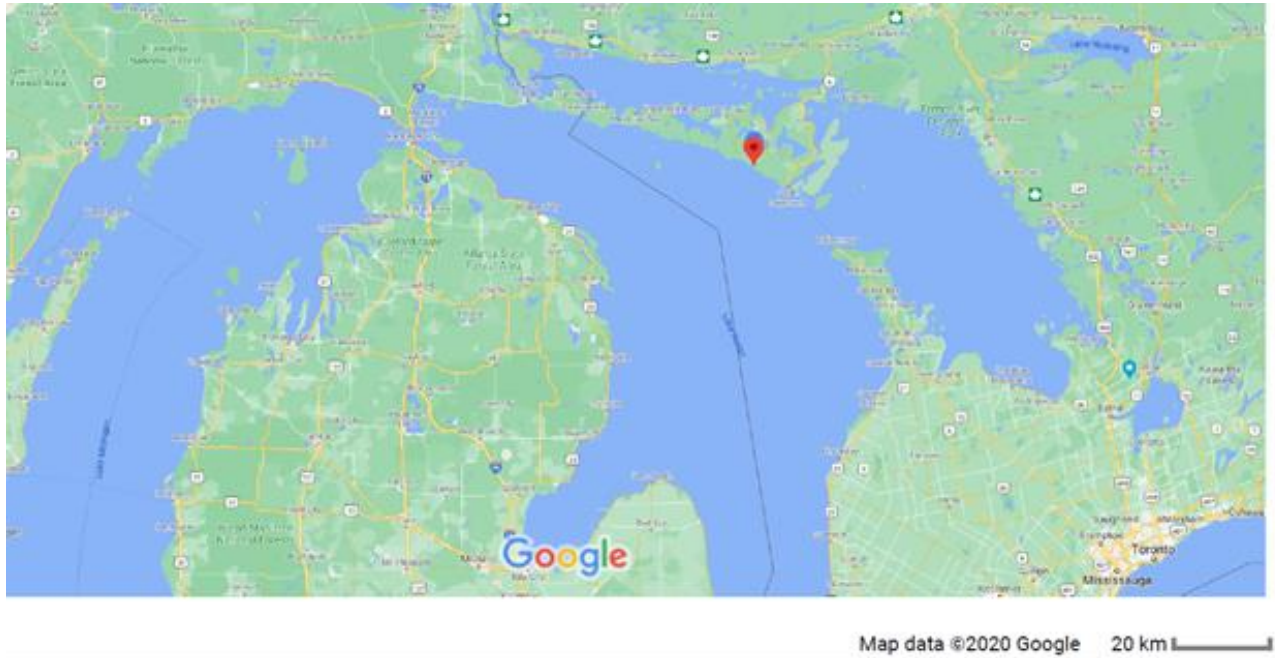
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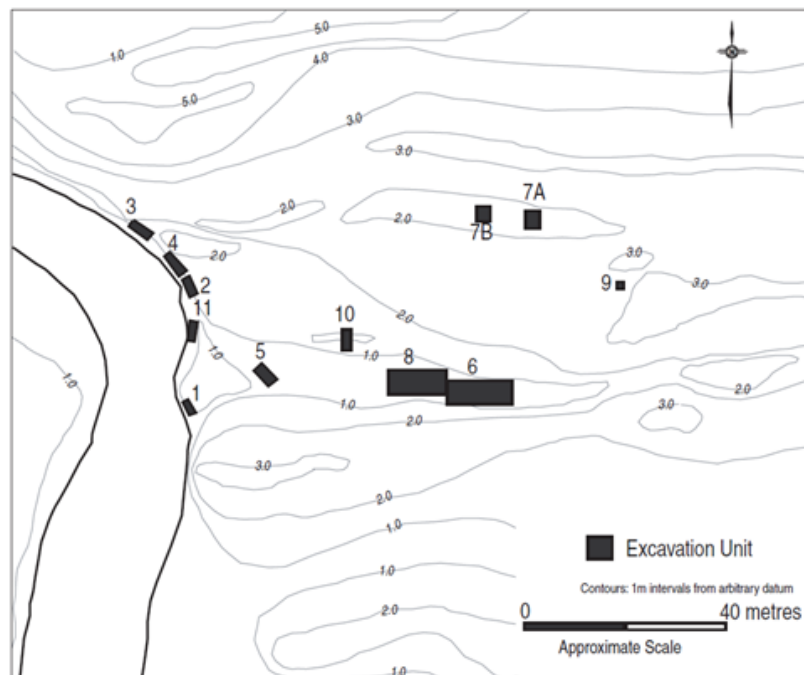
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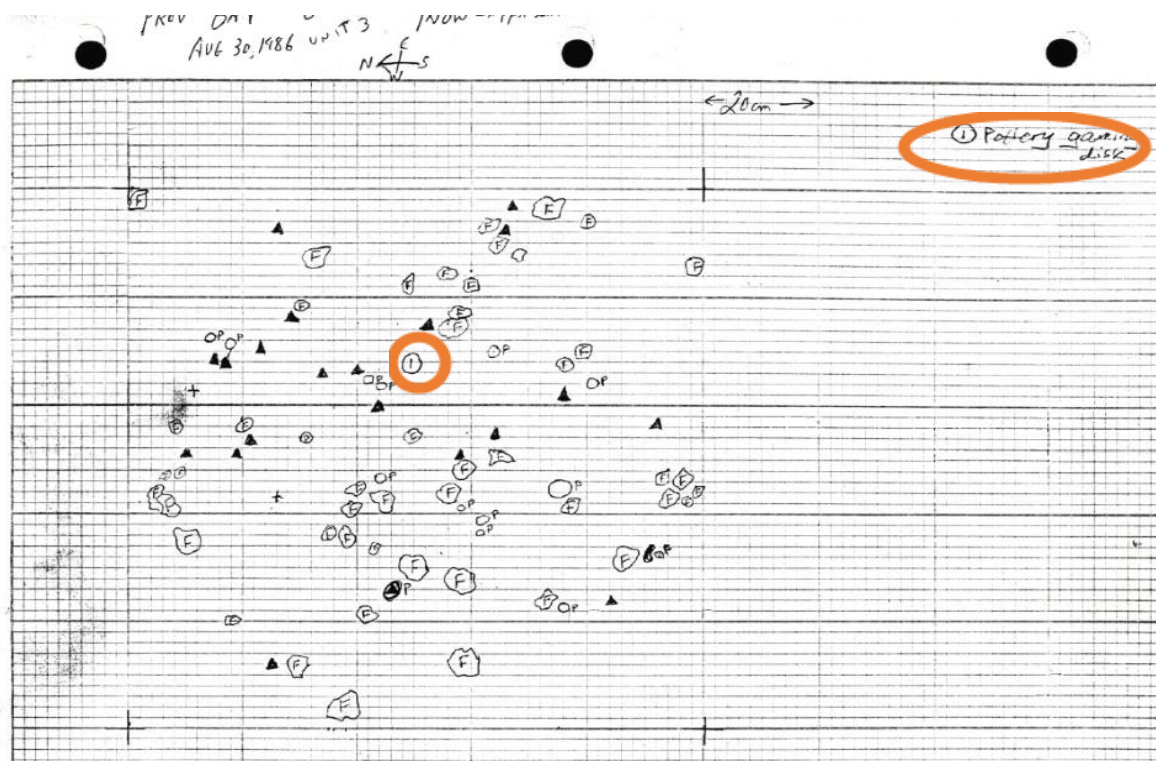
## Appendix A: Figures



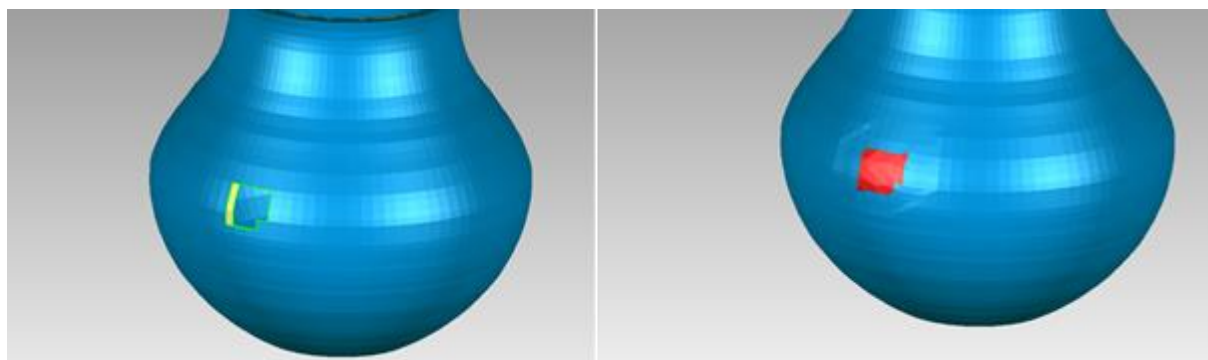
**Figure 2.1: Map of Lake Huron and Manitoulin Island indicating location of the Providence Bay site. Map taken from Google Maps.**



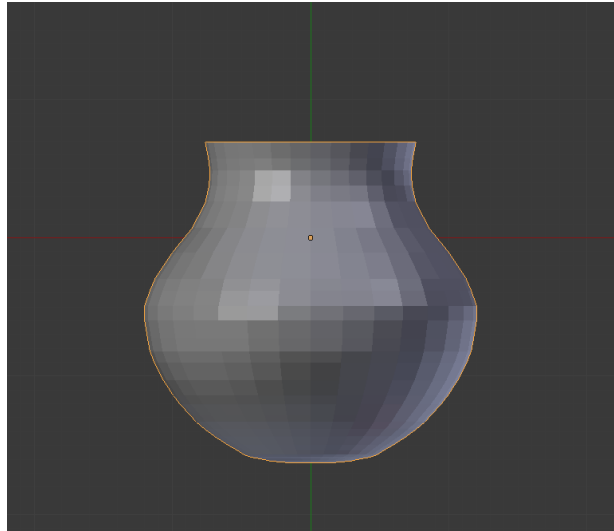
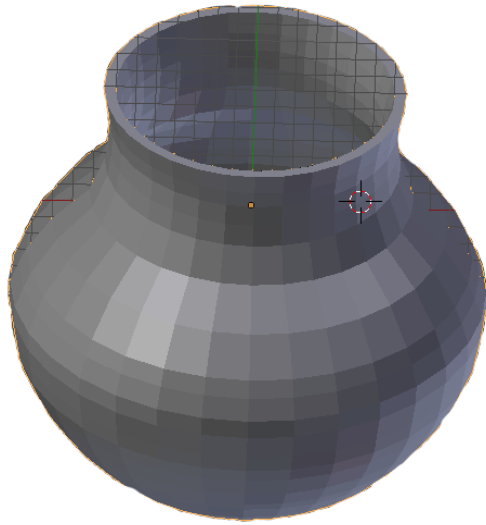
**Figure 2.2: A site map created by Smith and Prevec, indicating the approximate positions of excavation units on the Providence Bay Site. This map was taken from Smith & Prevec 2000:79.**



**Figure 2.3: Map of Unit 3 From Providence Bay Fieldnotes. An ID in the top right corner indicates that a "pottery gaming disk" was found in this unit. Image comes from field maps created in the 1986 field season at Providence Bay. Maps, at the time of this publication, are housed at the Museum of Ontario Archaeology.**



**Figure 2.4: An example of "hole filling." Figure 2.4 A shows mesh with a hole, while 2.4 B shows that the same hole was repaired with the automated process. Note the distortion of the mesh. Photo is of the vessel model used in this study, and is captured from Geomagic Studio to demonstrate the "hole filling" function.**



**Figure 3.1: The first Providence Bay vessel model built based on ceramic measurements.**



**Figure 4.1: An example of fragmentary ceramics from Providence Bay**





**Figure 4.2:** All sherds from “Algoma Lipnotch Vessel 97.” Note the high number of sherds under 3cm in length or width. The outer edge of the lip does not appear to feature punctates. Note the smooth surface on the rim sherds and the cord marking on the body.



**Figure 4.3:** Mended rim sherds that feature the incised notch decoration in the rim. Left, Rim 1, features two mended sherds while right, Rim 2, features three mended sherds.



**Figure 4.4: Body sherd featuring cord marking.**

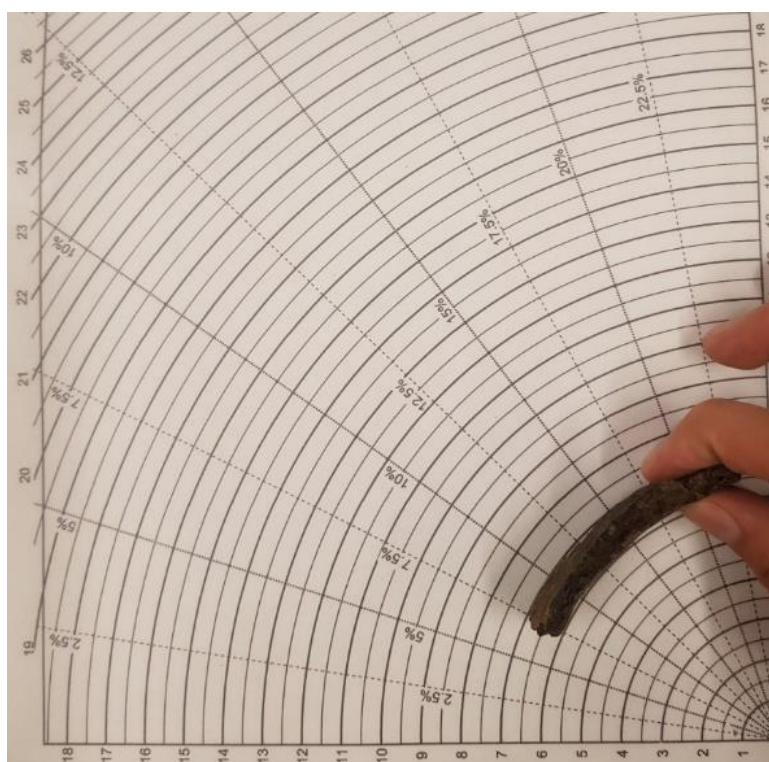


**Figure 4.5: All sherds selected for use in the modelling process. Rim 1 (top left), Rim 2 (top right) and Body 1 (lower centre).**

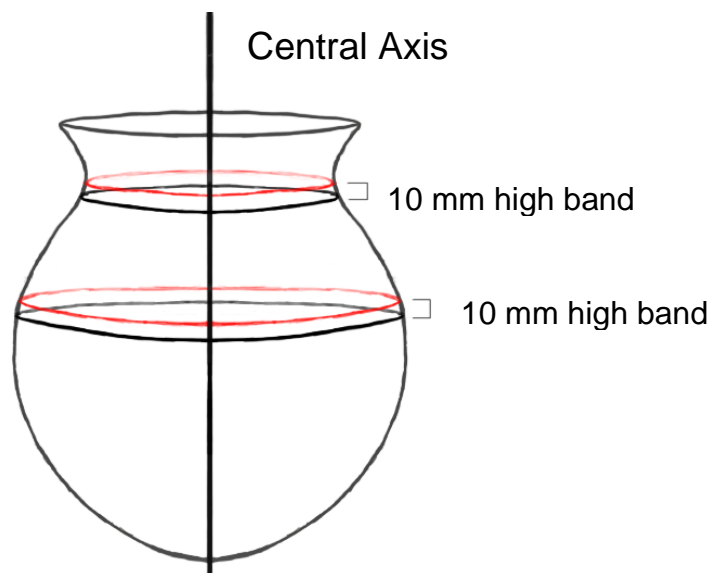




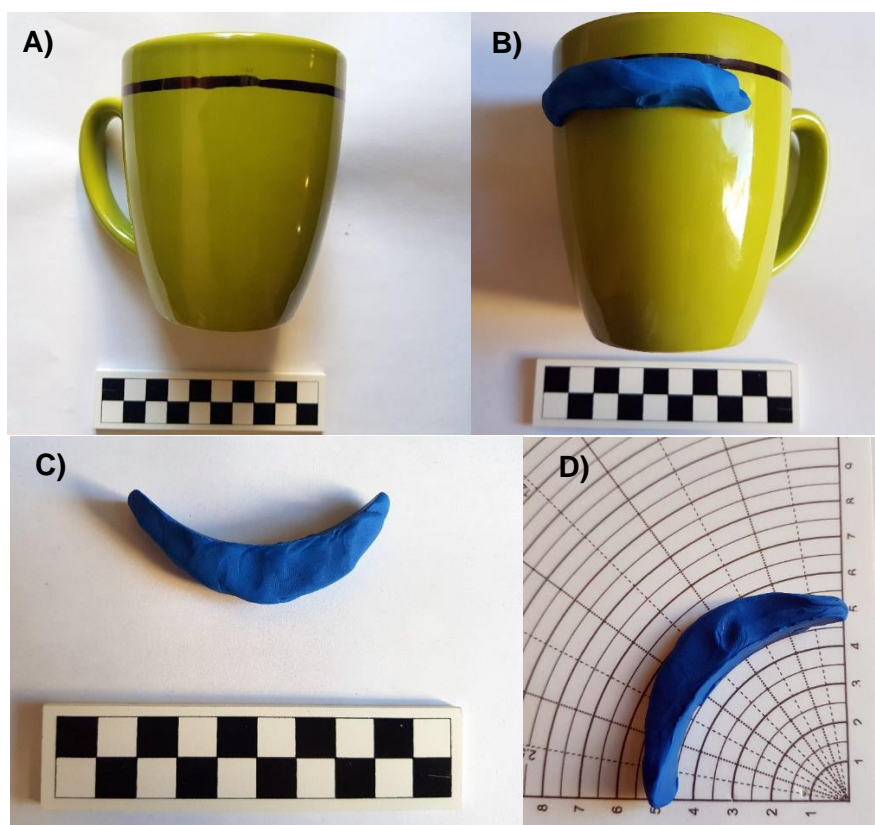
**Figure 4.6: All six of the excluded sherds. Top row (left to right) Body 3, Rim 3, Rim 4. Bottom row (left to right) Body 2, Body 4, Body 5.**



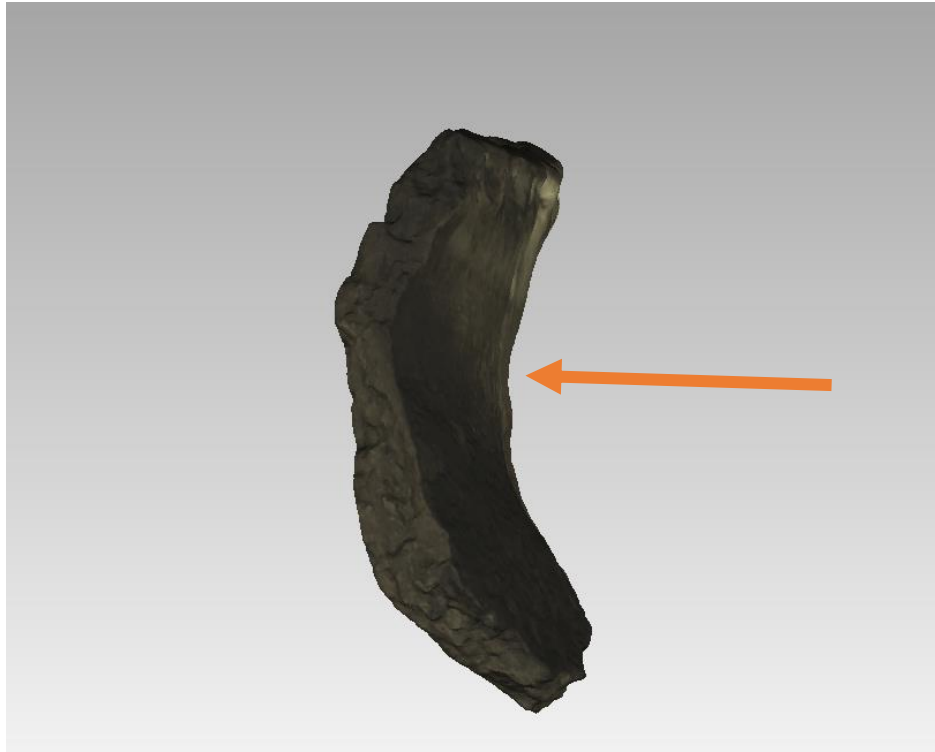
**Figure 4.7: Illustration of a Rim Diameter Chart. Image of Rim 2 held against a rim diameter chart. Note that I am measuring the curve along the exterior of the pot as the modelling process was primarily concerned with the exterior of the vessel**



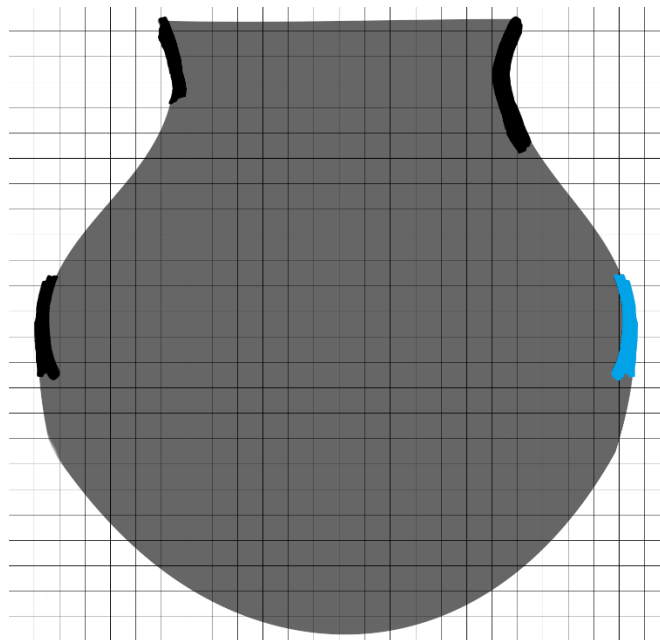
**Figure 4.8:** An illustration of the central axis of an imagined pot, based loosely on the shape of vessels assumed for Providence Bay. Diameters recorded for sequential bands along this pot form should provide perfect circles around a central axis.



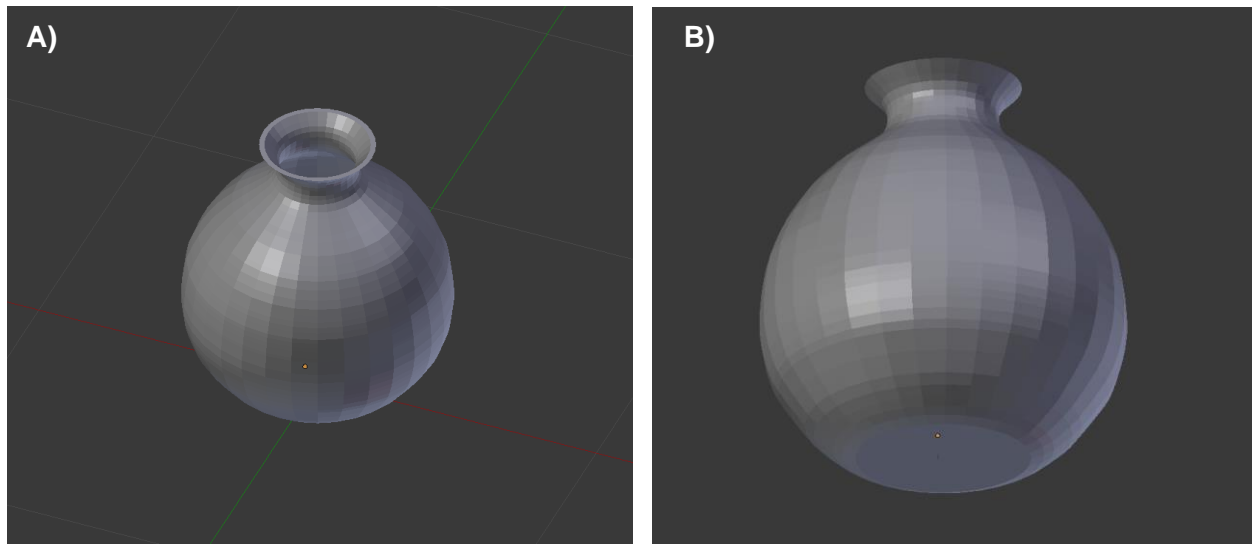
**Figure 4.9:** The process of capturing curvature along a band of a vessel using modelling clay. Figure 4.9 A shows the band marked on the mug for the sake of clarity. 4.9 B shows the clay impressed onto the mug surface, 4.9 C shows the clay removed from the mug surface with the curve captured, and 4.9 D shows the curve against the rim chart.



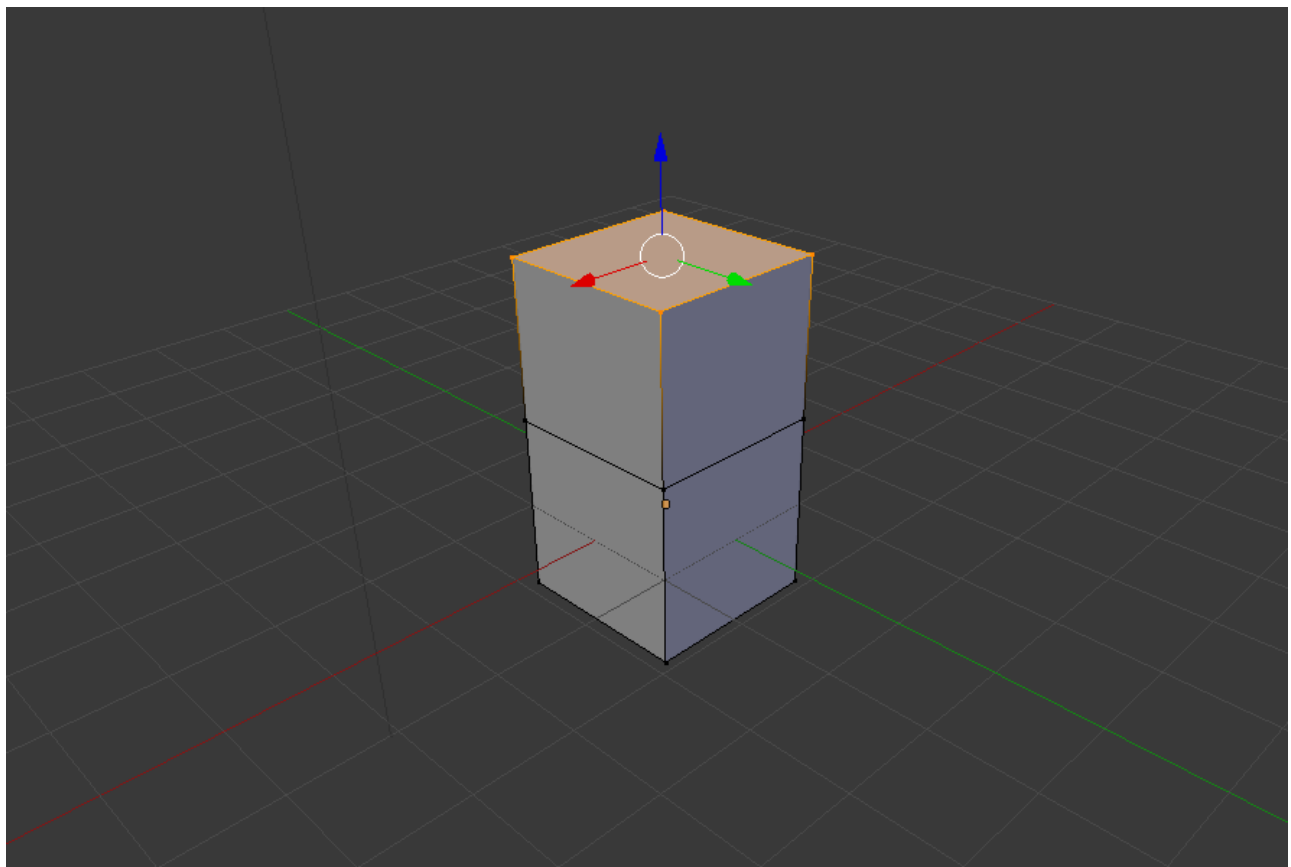
**Figure 4.10: Side view of Rim 1. The orange arrow indicates the narrowest point of the neck, which is captured in the diameter contraction evident in Band 2. Below this point, the vessel profile curves back outwards, down the next two recorded Band diameters.**



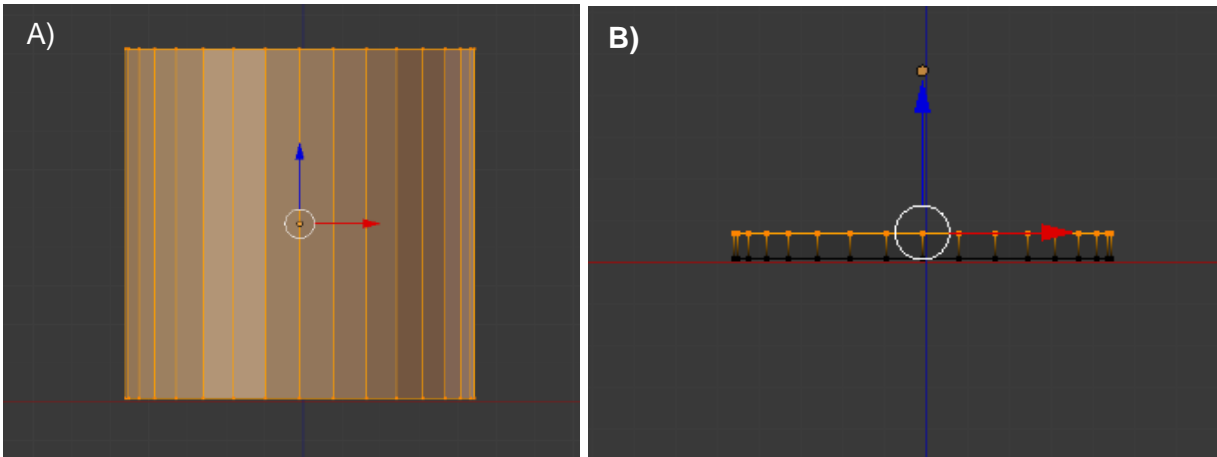
**Figure 4.11: Vessel profile of the Heart Pot, a rough sketch of the vessel's shape using measurements from sherds and speculation on those attributes of the vessel form that were not knowable from artifacts. Silhouettes of sherds used in this thesis are featured in black. The blue body sherd is a mirror of Body Sherd A.**



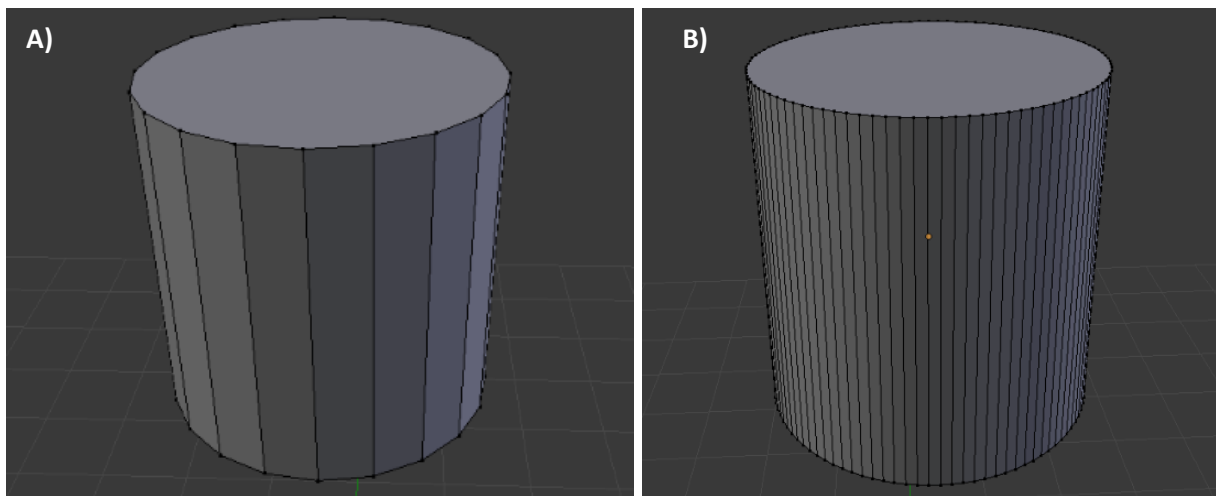
**Figure 4.12: 3D model created in Blender of a generic vase (no relation to Providence Bay). A horizontal cross-section passing through the central axis of this vessel will be a perfect circle. A vertical cross-section through the central axis would also create two halves that mirror each other.**



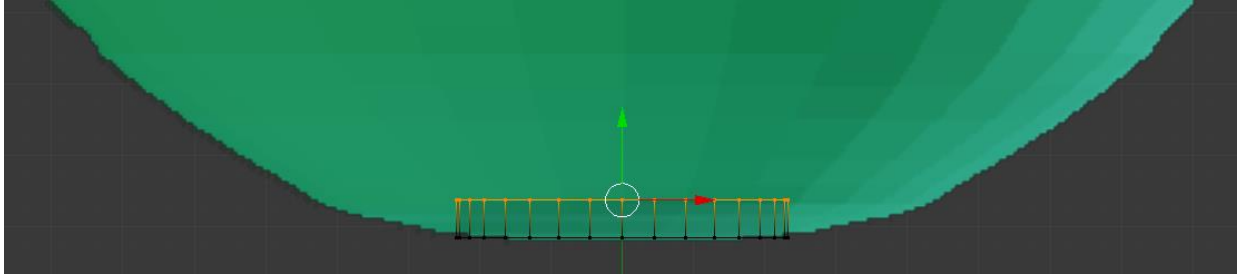
**Figure 4.13: An example of extrusion. The upper cube has been extruded from the lower cube, by selecting the orange face and edges that were then extruded in a vertical direction, All model surfaces, original and duplicated, are now part of the same object.**



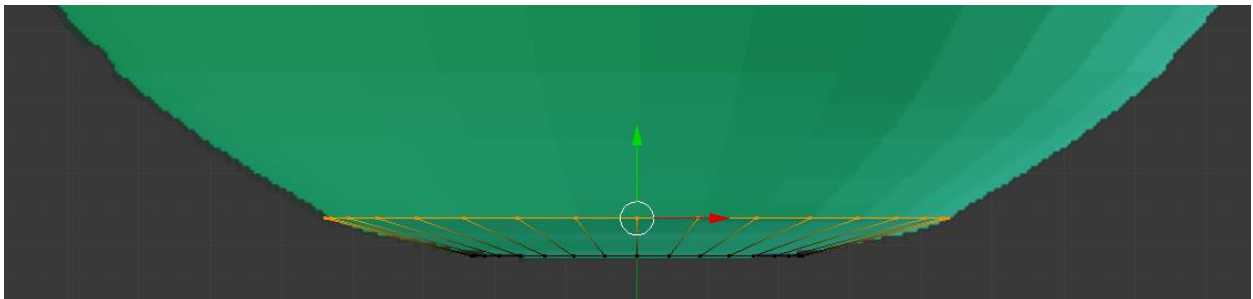
**Figure 4.14:** Two images taken from blender illustrating the resizing of a cylinder. The arrows indicate the vertical (blue) and horizontal (red) axes. A) A solid cylinder with faces filled in in “edit mode” depicts the first cylinder I started with. B) depicts that cylinder with transparent faces resized into a pot layer to begin extruding new layers vertically. A layer must be thin on the vertical axis to ensure the final model is visually smooth.



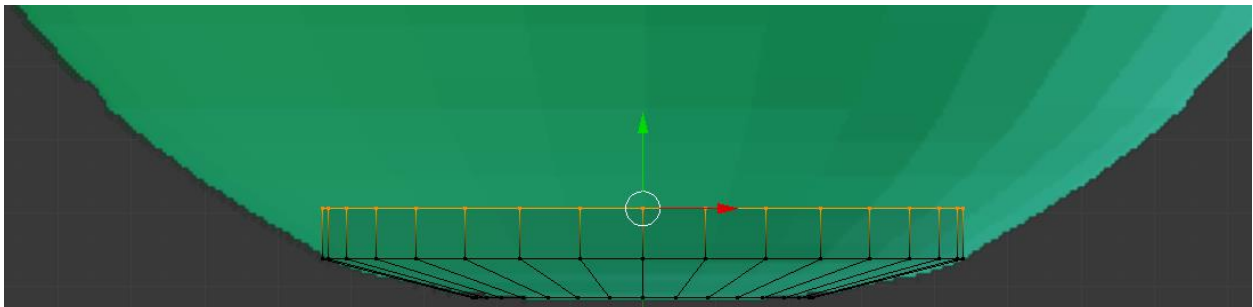
**Figure 4.15:** Two cylinders modelled in Blender. Cylinder A has 20 vertices, meaning each circle has 20 faces that are connected by corners for a total of 40 vertices. Those corners create the flat, angular faces of the object. When printed, each of those faces will feel like a flat surface. Cylinder B has 100 vertices. Its faces are still flat and angular, though they are much narrower and, if printed, would feel much smoother to the touch.



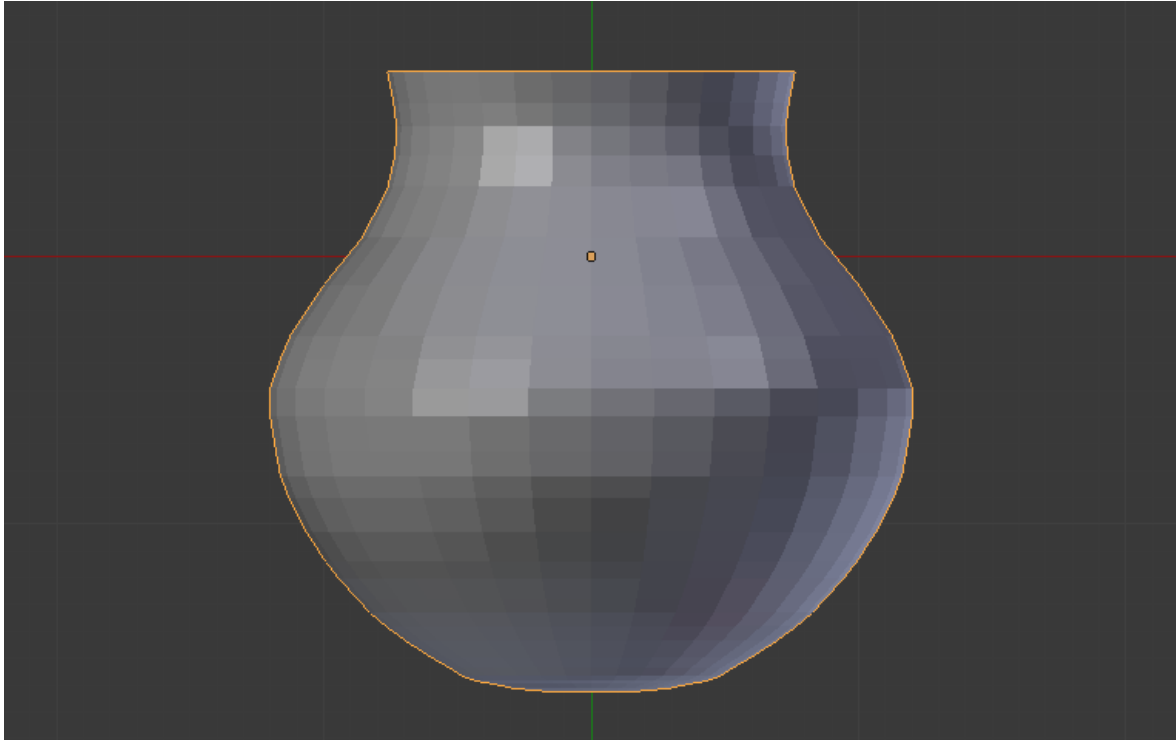
**Figure 4.16 A:** Early stages of a mesh model being built with an image for reference in the background. The image of the earliest Heart Pot has been false coloured for clarity. The cylinder used here also had 36 vertices for ease of viewing. The band currently being worked with is highlighted orange. The orange band at the top is the first to be resized



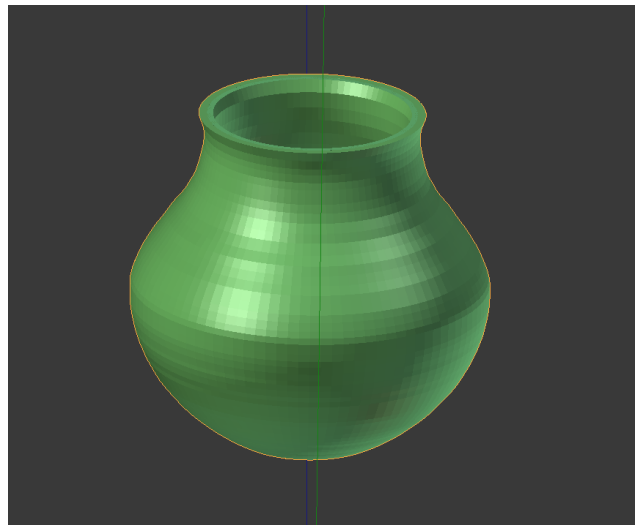
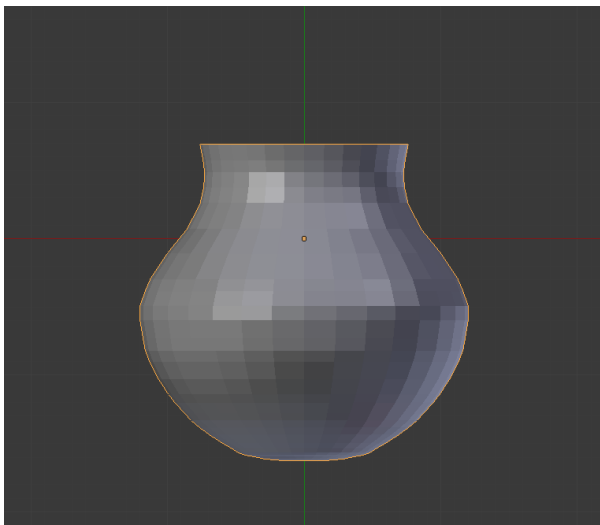
**Figure 4.16 B:** The band from the previous image has now been resized to fit the curve of the reference image it is copying.



**Figure 4.16 C:** A new band has been extruded from the band in 18 B.

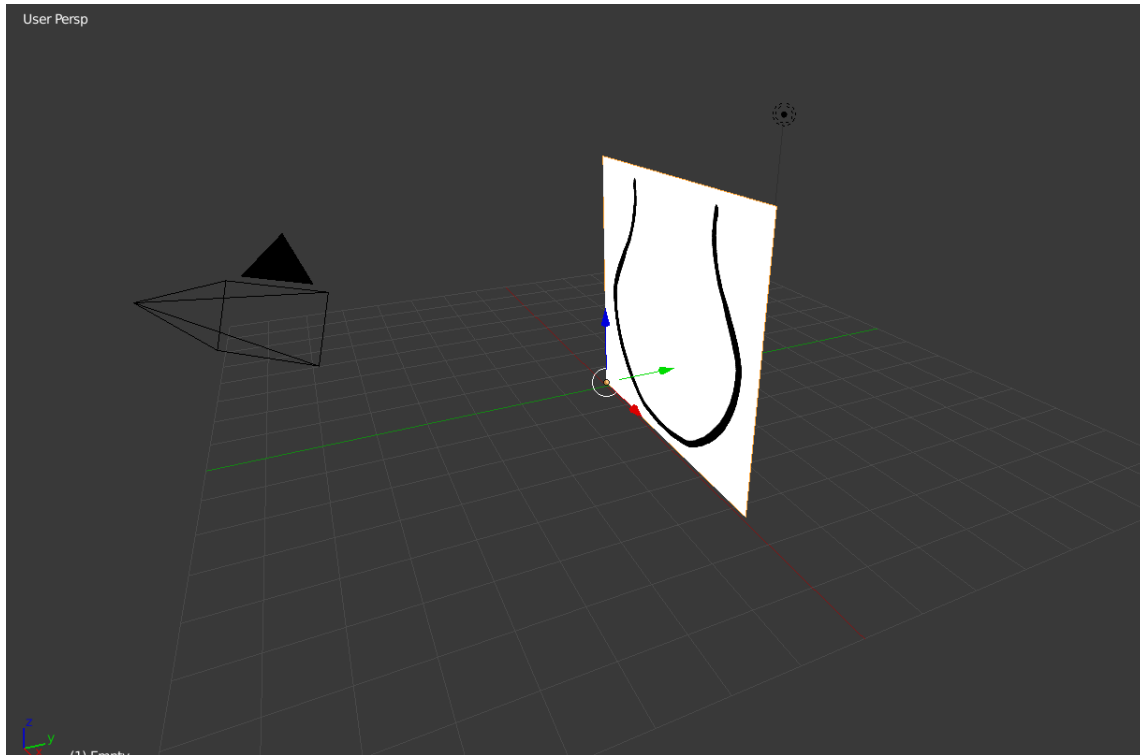


**Figure 4.17: The first model of the Heart Pot built approximating the vessel measurements from Table 2.**

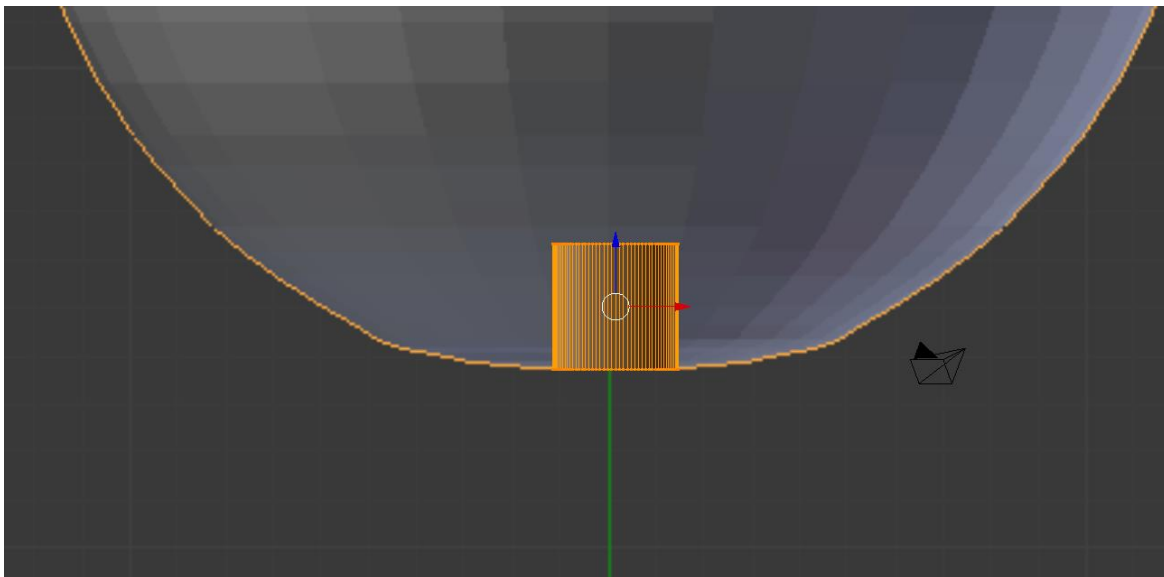


**Figure 4.18: The first model of the Heart Pot beside a later version with 100 vertices**



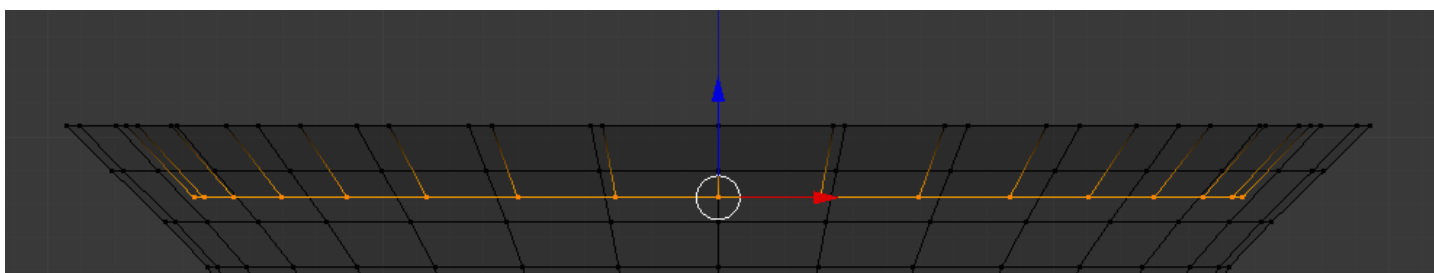


**Figure 4.19:** An image in the Blender Scene. This image file is considered “empty” meaning it has no mesh or geometry, making it useful for reference while modelling. The cylinder would be positioned in front of the image and new bands would be extruded and resized to match the image positioned behind the mesh.

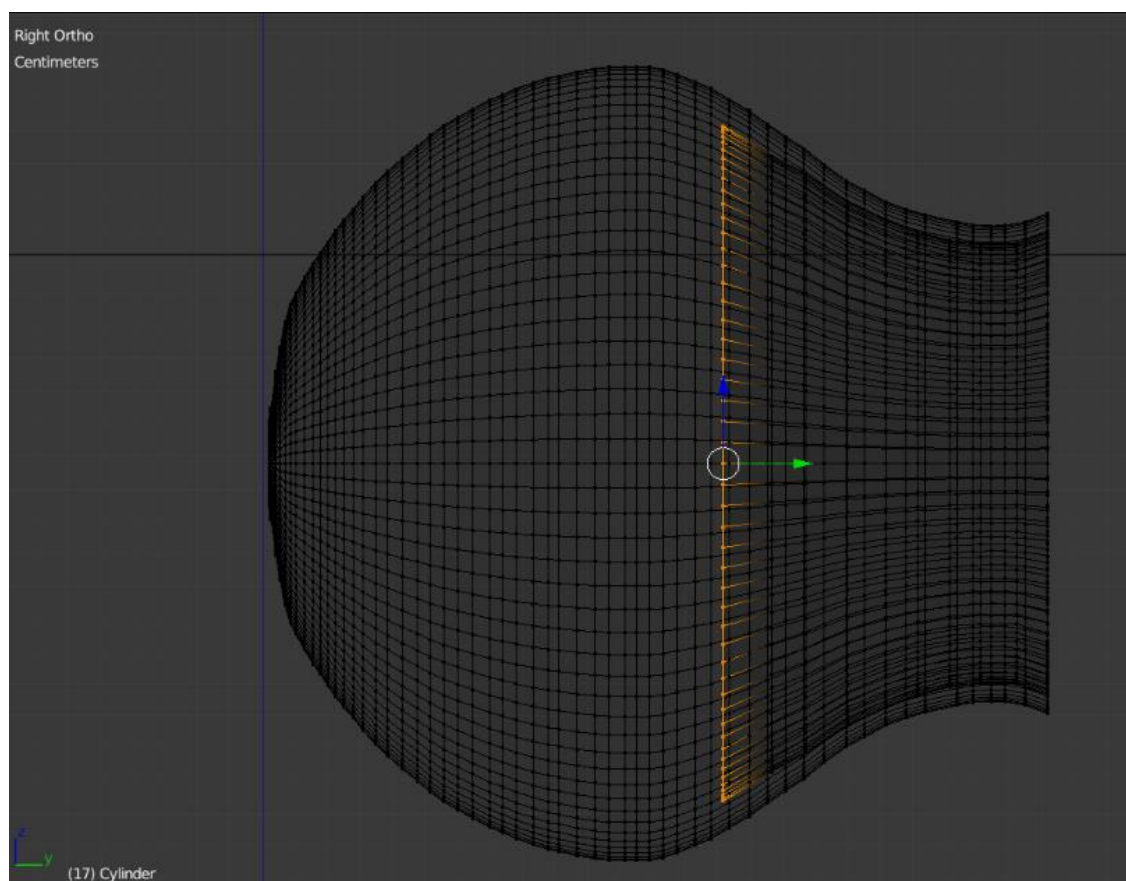


**Figure 4.20:** An image from Blender of the base of the first iteration of the Heart Pot positioned in a scene. The image seen behind the orange cylinder is scaled to the estimated vessel dimensions. The orange cylinder will be resized to create a first layer of the next iteration of the model, and additional layers will be extruded out from it to copy the silhouette of the vessel in the image.





**Figure 4.21:** A layer extruded downwards into a vessel (generic vase) to begin hollowing out the model to create interior dimensions. Orange points represent the new layer. Note the new layer is smaller than the wider, exterior layer and extends downward toward the base of the vessel.



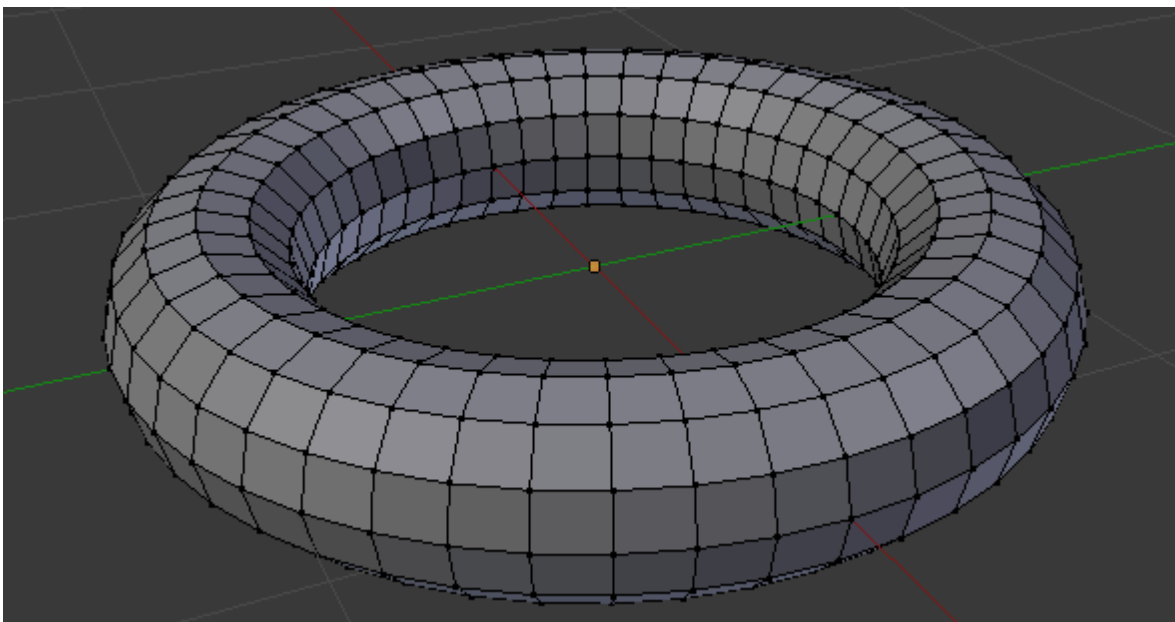
**Figure 4.22:** A side view of the heart pot with half of the interior volume has been removed. The extent of the removed interior is visible above the orange band (direction of green arrow). Everything below that is still solid in this image. Note the thickness of the walls that appear to be a lighter grey.



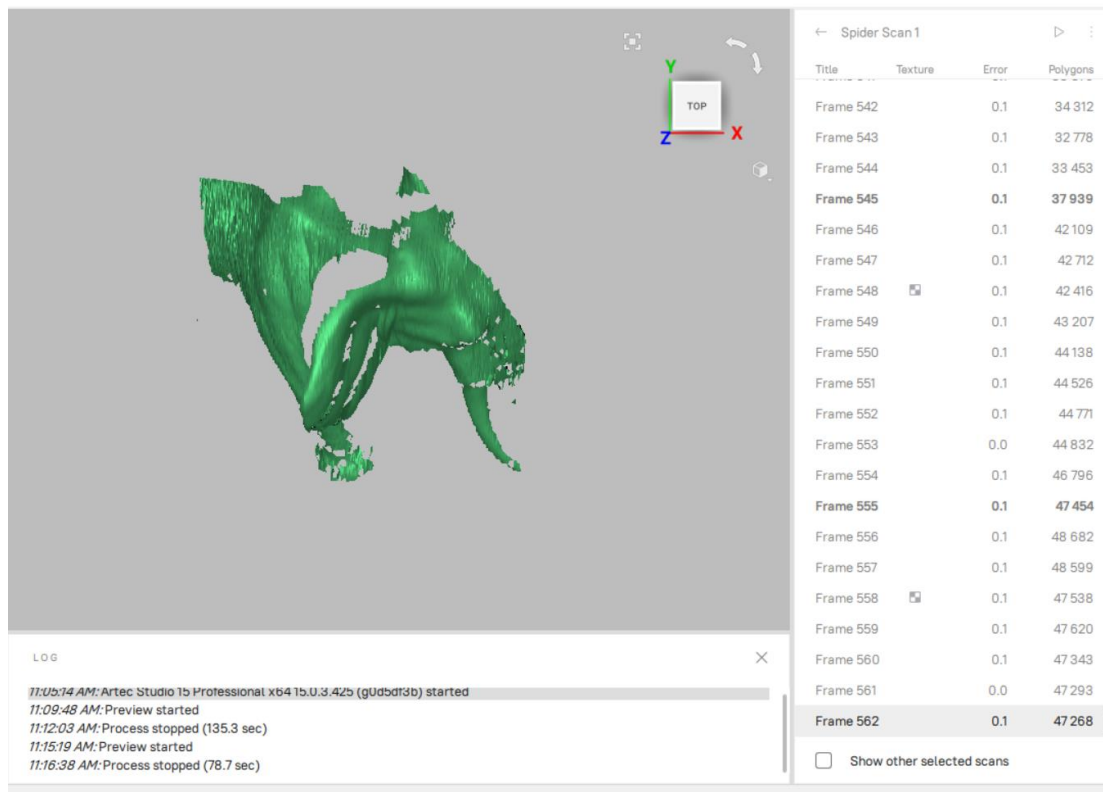
**Figure 4.23: A side view of Body Sherd A, note the increasing thickness toward the left (toward the base of the vessel).**



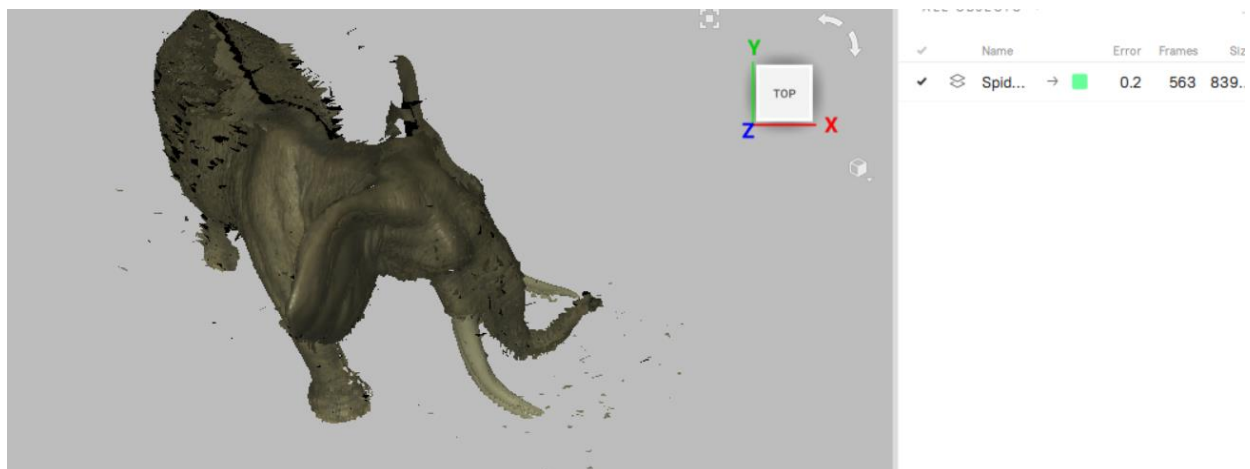
**Figure 4.24:** A cross section of model 2 of the Heart Pot.



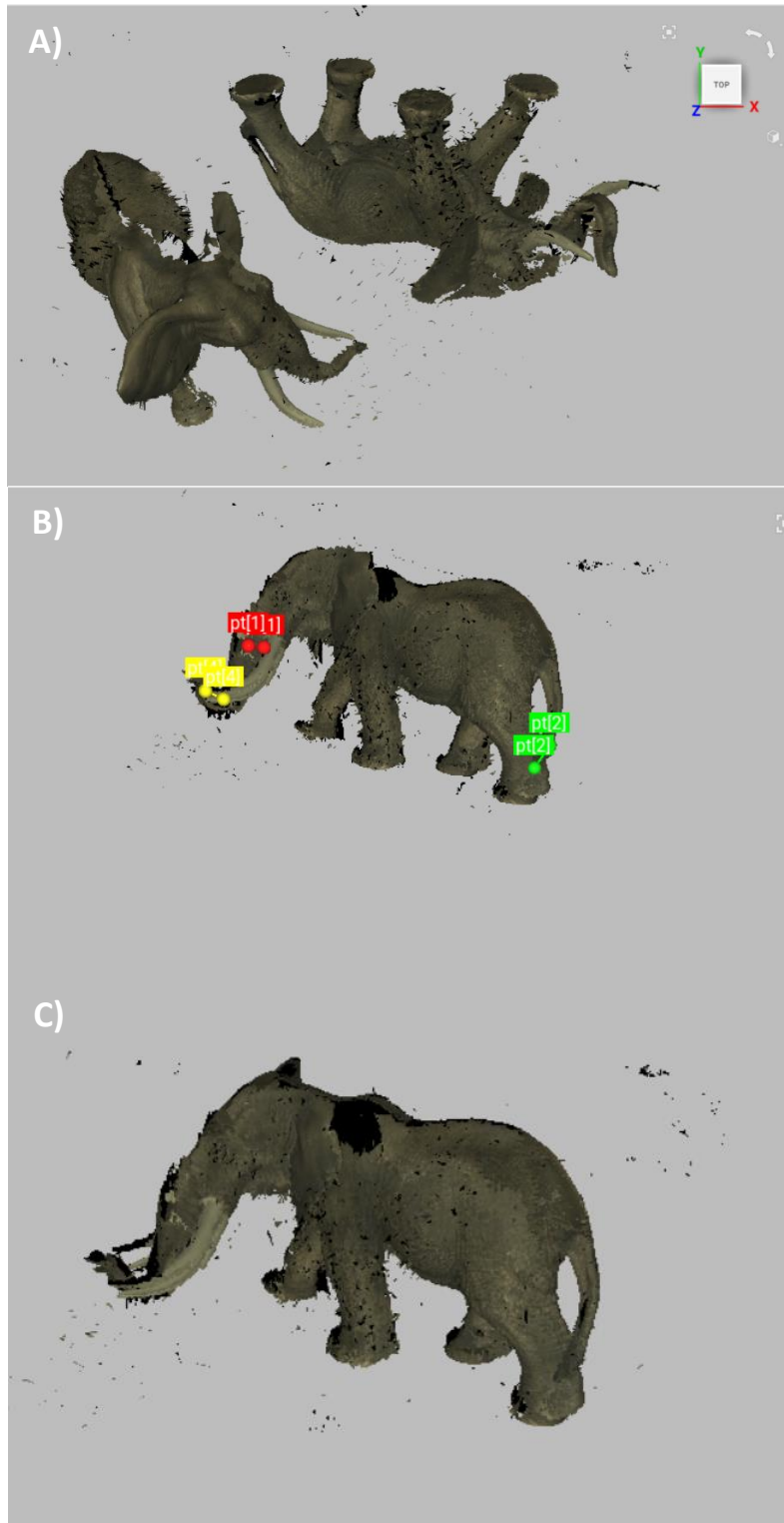
**Figure 4.25:** Model of a torus mesh captured in Blender. All lines are edges, the corners where edges connect are vertices, and the flat grey surfaces are faces.



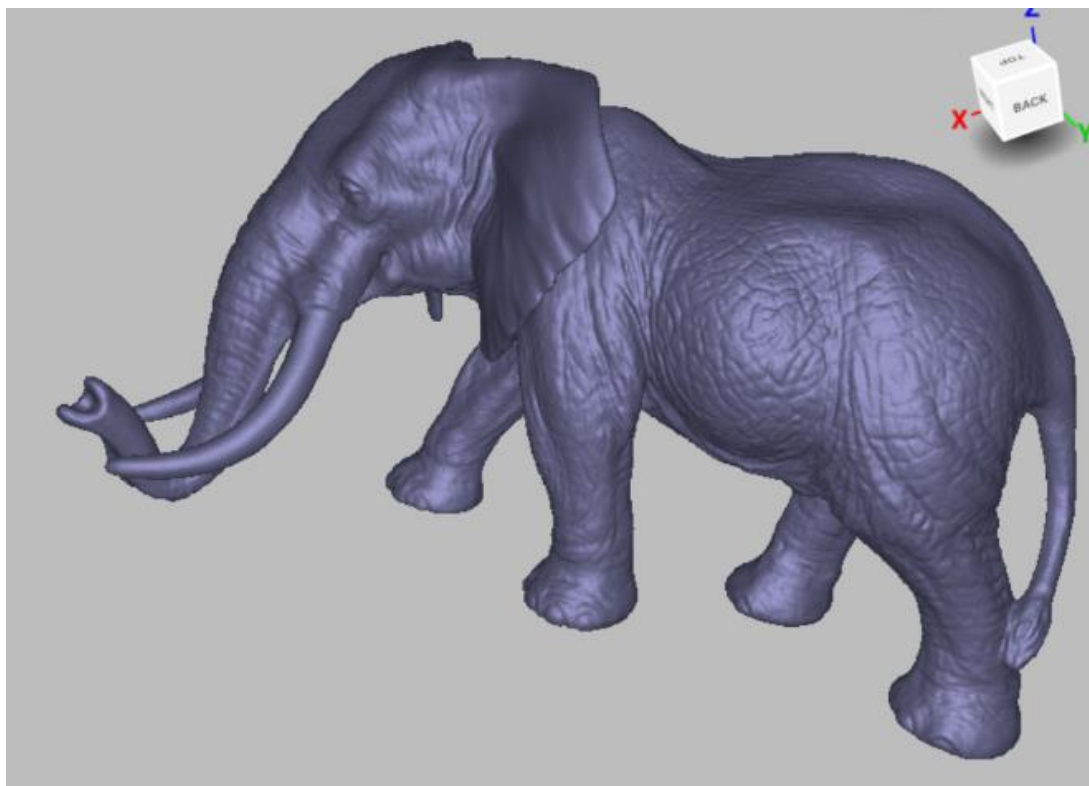
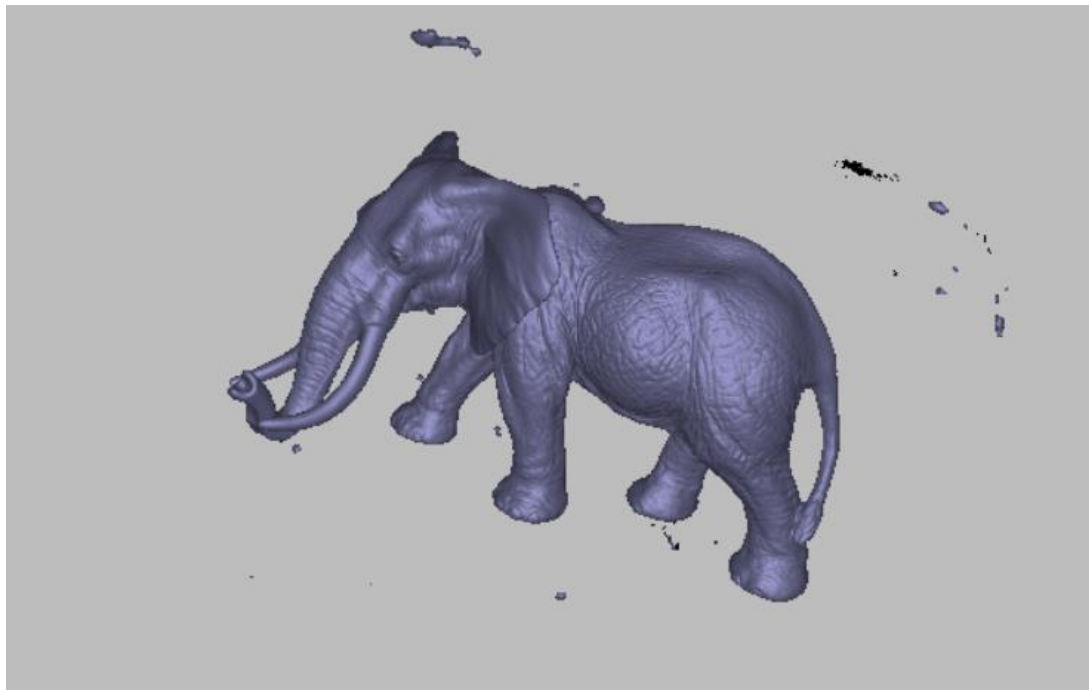
**Figure 4.26:** Image of a single frame of the test elephant scan from Artec Studio 15. This single frame is one of the 562 that were captured and stitched together in a single scan session. In order to complete digital 3D model of this elephant, two scan sessions were completed.



**Figure 4.27:** A single completed scan session of the test elephant in Artec Studio 15. Sections of the object not captured in this orientation will be captured in the next session.



**Figure 4.28:** Images of a plastic elephant in Artec Studio 15. Image A illustrates the partial models created over two scanning sessions of the elephant, while image B shows the two models following the selection of common points and the alignment of those points. Image C shows the elephant after the automated alignment of the models has been performed.



**Figure 4.29: A fused image of the test elephant. Figure 4.29A shows the test elephant with small objects that surround it. Figure 4.29B shows that these small objects have been filtered out.**

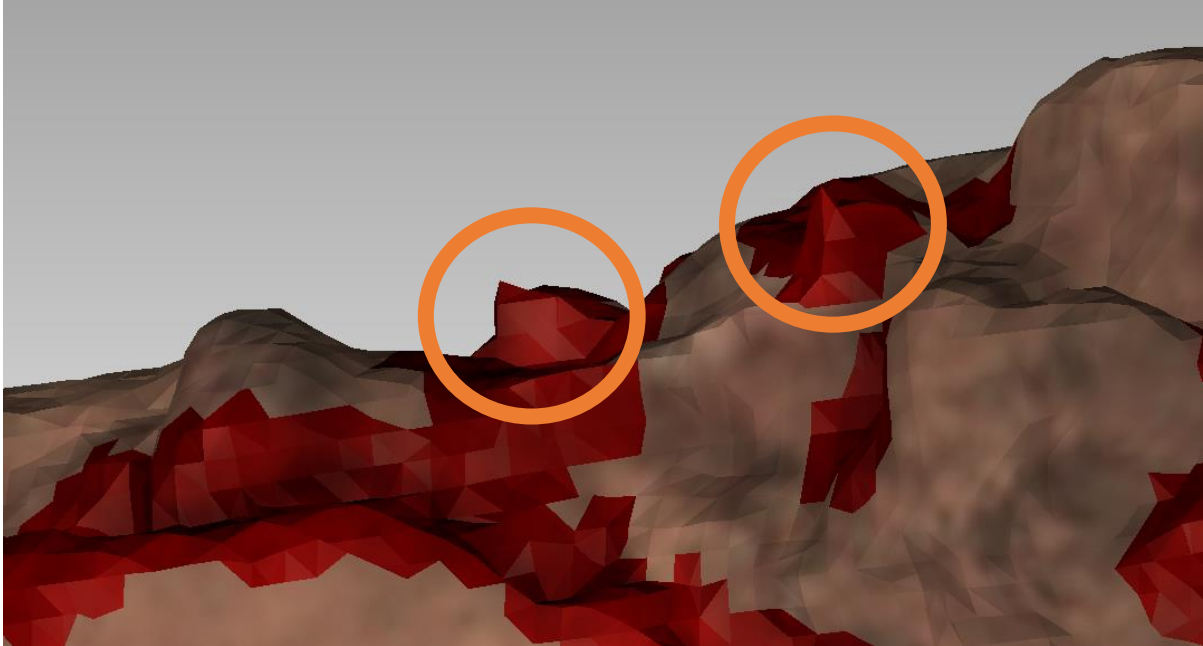




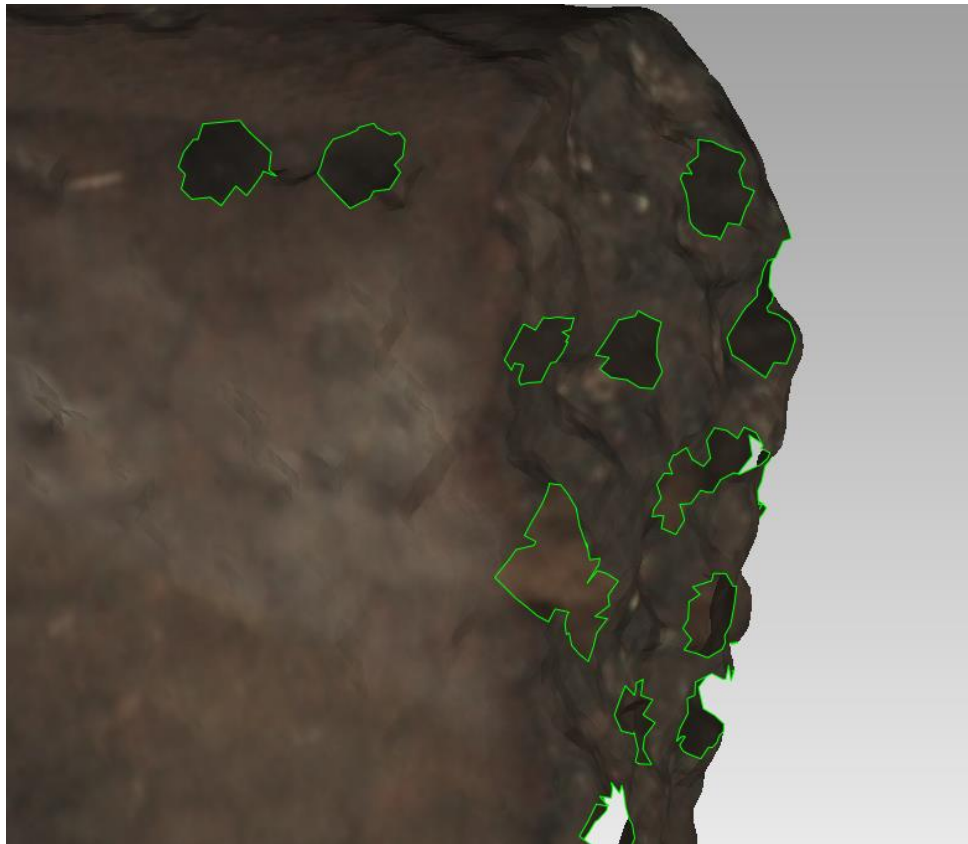
**Figure 4.30: Rim 1 propped against a neutral coloured support that has been secured to the foam base with masking tape to prevent shifting. Note the considerable portion of the sherd that is not obscured by the support.**



**Figure 4.31: The same rim after a 180-degree vertical rotation.**

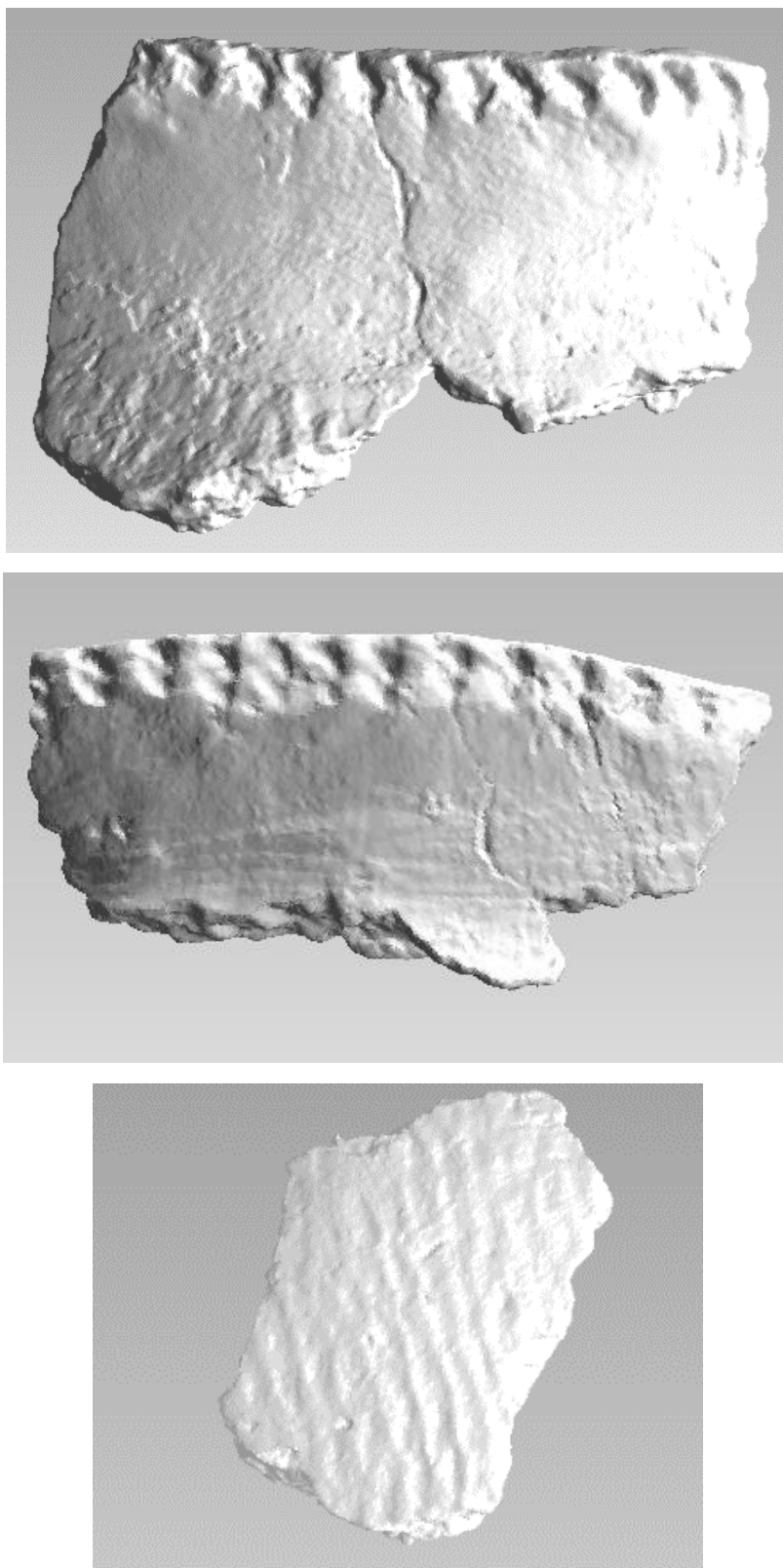


**Figure 4.32: Spikes circled. Note the sharp projection away from the model mesh. Image captured in Geomagic Studio 12 on a model of Rim Sherd 2 before Mesh Doctor was applied.**

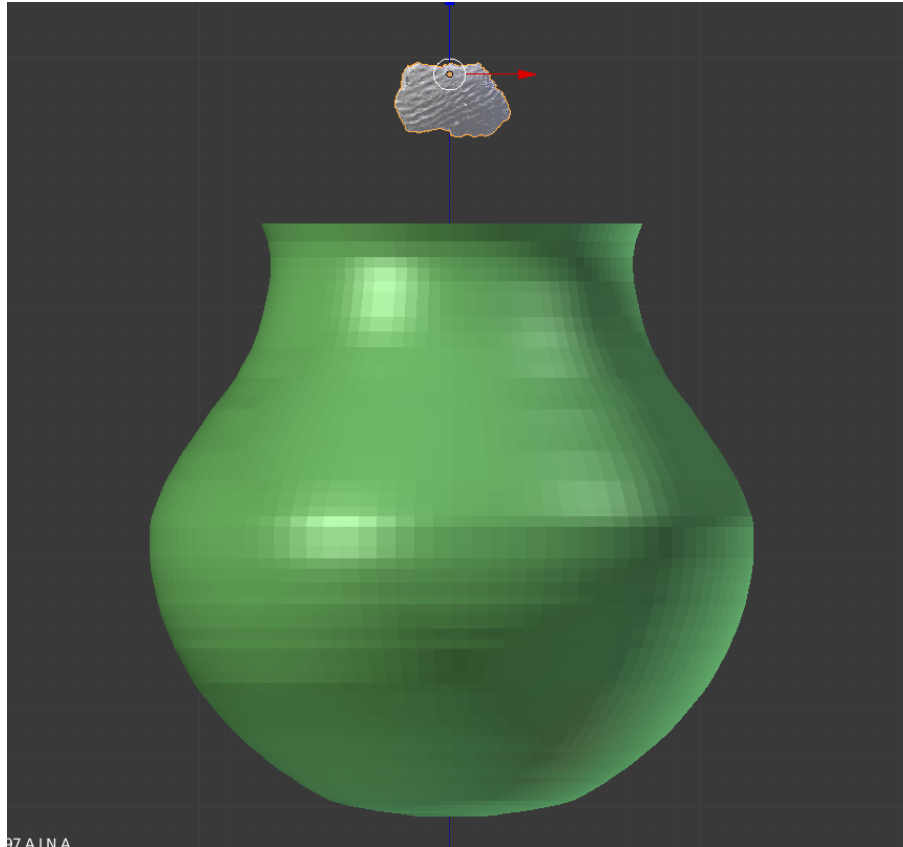


**Figure 4.33: Small holes on the edge of a model outlined in green, image captured in Geomagic Studio 12 of Rim Sherd 2.**

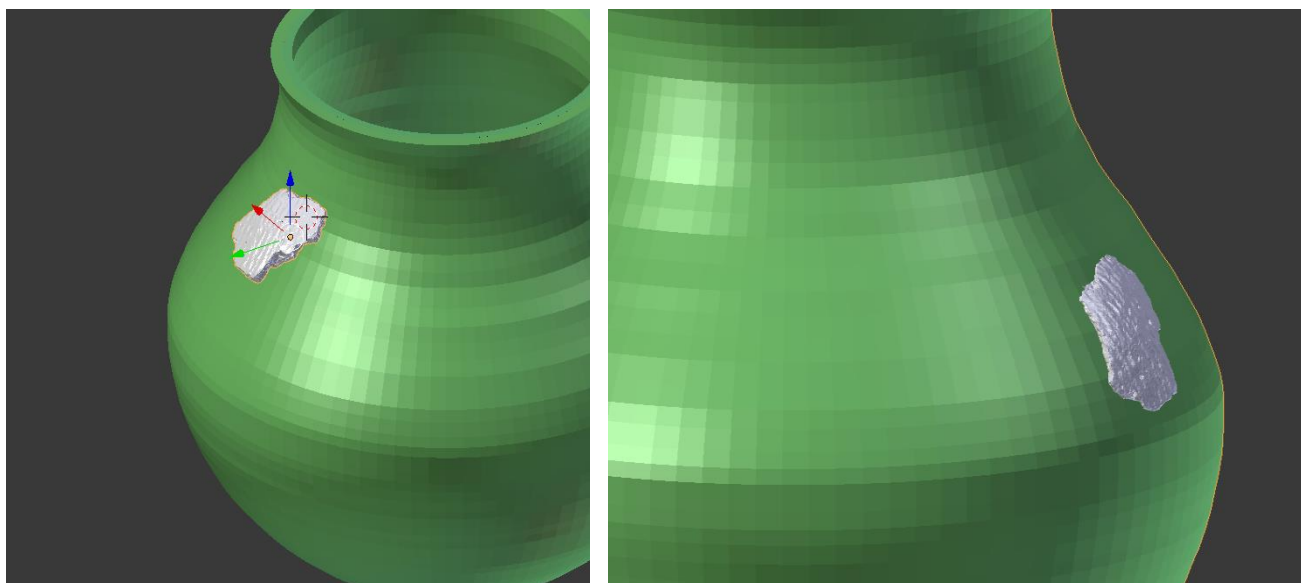




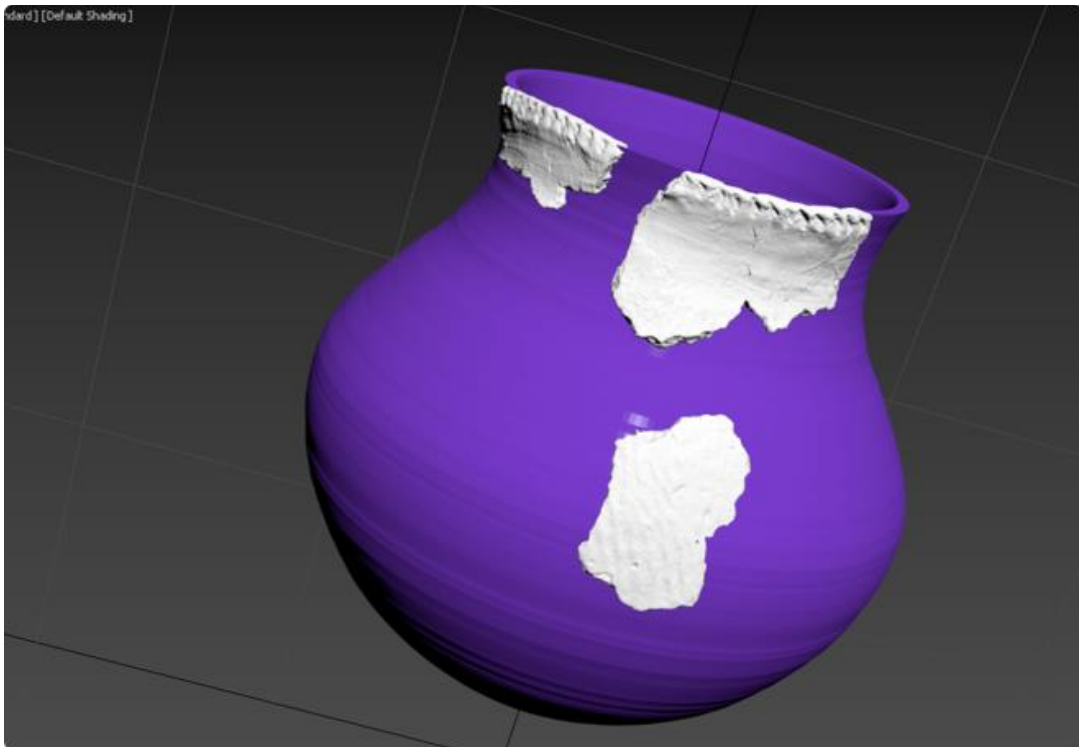
**Figure 4.34: Final scans of Rim 1 (top), Rim 2 (middle) and Body A (lower)**



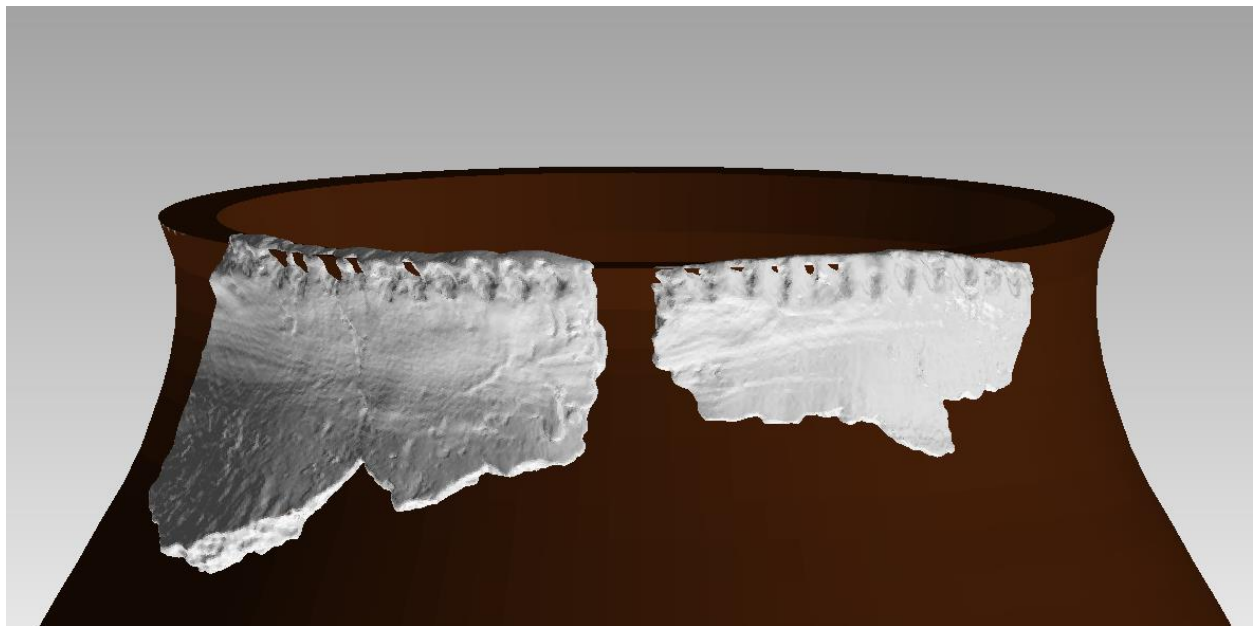
**Figure 4.35:** A scaled sherd imported into the scene with the Heart Pot. The sherd here has not been rotated or otherwise positioned in relation to the pot (Image taken from a later iteration of the Heart Pot).



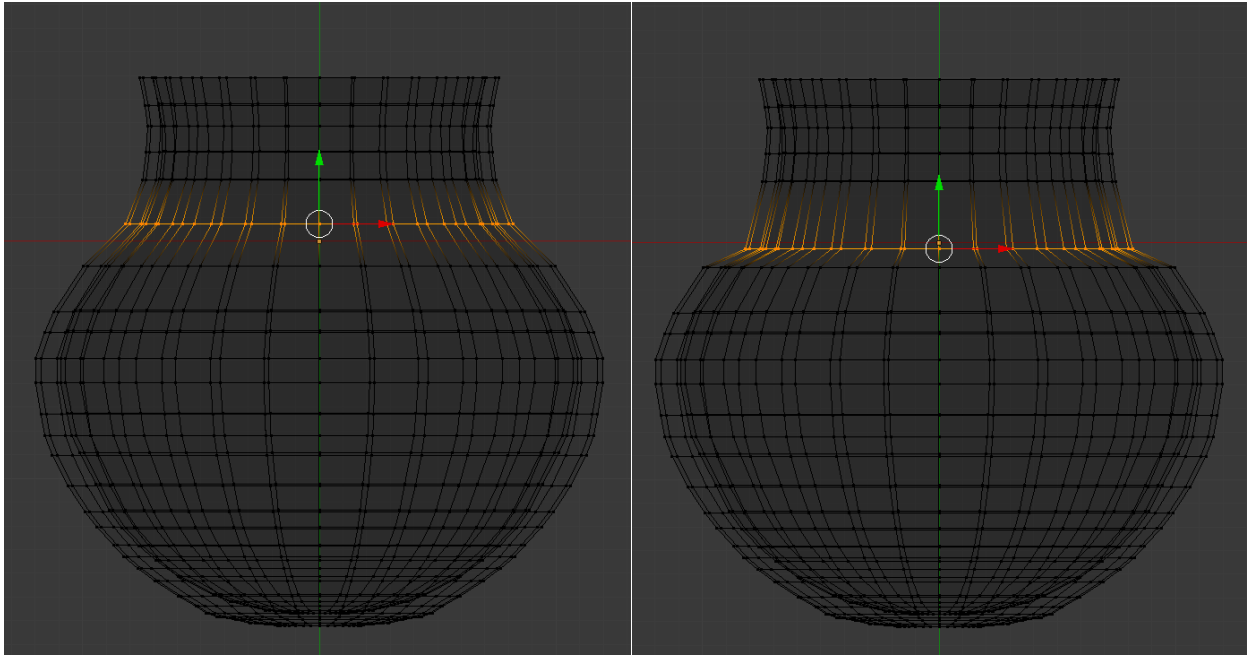
**Figure 4.36:** Positioning a sherd on the model then lowering it into the model's wall to position it and create a composite of the two objects (Note: Image taken from a later iteration of the Heart Pot to simply illustrate the process in this figure).



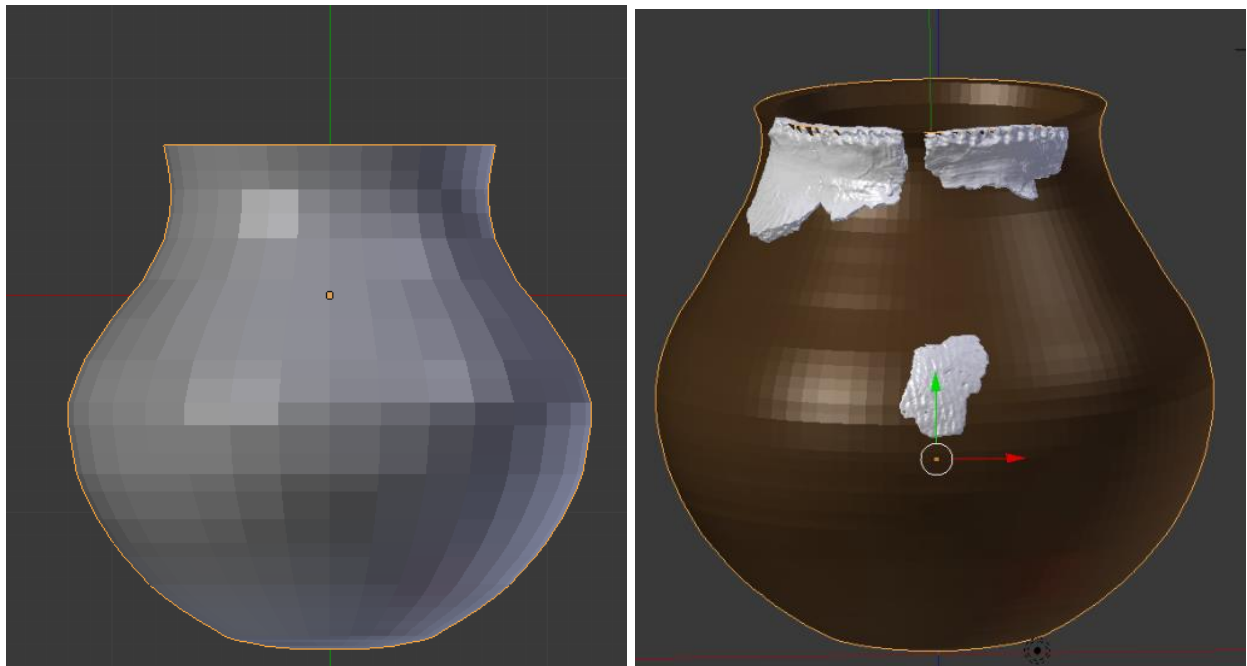
**Figure 4.37: Rough merge with 3D models of sherds that were not accurately scaled. I used this iteration to facilitate discussion with the OCF at this stage in the process.**



**Figure 4.38: The upper lip of Rim Section 2 (right) appears to have a convex curve along the lip compared to the model, while Rim Section 1 (left) appears to be more aligned with the flat lip of the modelled rim. At the same time, Rim Section 1 exhibited a sharper neck curvature than Rim Section 2.**



**Figure 4.39 A:** Front view of the early mesh model of the Heart Pot in Blender. **B:** The highlighted layer has been dramatically shortened. This shortening caused a chain reaction below the adjusted neck. Notably, it created a sharper demarcation between neck and shoulder, which necessitated further adjustments. Note That the adjustments in Figure 4.39B have been exaggerated for illustrative purposes.



**Figure 4.40: A)** The first iteration of the Heart Pot based on sherd measurements and vessel estimations. **B)** The final iteration of the Heart Pot after the final version of the sherd merge. The model made after the merge features a slightly shorter dramatic neck and wider body.



**Figure 4.41: A) A photograph of Rim 2; B) The texture map created of Rim 2 post scanning; C) image of the final Heart Pot after applying the colour to the pot surface.**





**Figure 4.42: The print bed in its lowest position. As the printer adds additional layers of powder, the bed drops lower to accommodate this new material. The dimensions of the bed are as follows: Length-254mm, Width-381mm, Height-203mm**



**Figure 4.43: Photograph of the 3D print of the Heart Pot.**



**Figure 4.44:** Close up photograph of the Heart Pot. Note the slight gap where Rim 1 sticks out from the model. Also, note the circular pattern that can be seen on the model surface. Each circle is the result of a single layer of powder that has been deposited when printing out the pot.



**Figure 4.45:** Recreating the hand position found when Holding the Heart Pot for the first time.

# Appendix B

## Aahnkesjihgeh Method for Non-Destructive Reconstruction of Ceramic Vessels

### Introduction

This guide, created in partnership with the Ojibwe Cultural Foundation, will allow users to construct an approximate model of a fragmentary ceramic vessel. This guide will go over the steps needed to create a rough sketch of the shape of the vessel and a more refined model. Refined models can be used in combination with 3D models of ceramic sherds/shards to create a printable combined model.

This method is most effective when working with sherds from different points of the vessel's profile.

### Materials

- Rim Diameter Chart (<http://potsherd.net/atlas/gallery/topics/rimchart-90.pdf>)
- Pencil and paper
- Ruler
- Ceramics to be measured
- Computer (Windows 8+, macOS 10.12+ or Linux) with minimum specs:
  - Processor: 32 bit dual core **2Ghz CPU or greater**
  - 4GB RAM
  - Graphics Card with 1GB of VRAM
  - Mouse
    - Determine Specs on Windows 10 by opening “Settings”, navigating to “System” and scrolling down to “About”. Specs will be listed under “Device Specifications”
    - Determine Specs on macOS by clicking on the apple logo in the top left-hand corner of the screen and click the first option “about this mac”. Specs will be listed under “Overview”
    - Determine specs on Linux by running “command line” and using the *lspci* and *lscpu* commands
- Blender (<https://www.blender.org/download/>)
- Materials for scanning (Optional)
  - Digital camera or cellphone
  - Computer with minimum specs
  - Software: Agisoft “Photoscan” or “Metashape”

### Terminology

- **Edges:** define boundaries of faces, edges connect vertices
- **Extrude:** to produce material out of a surface
- **Faces:** a flat surface that is bounded by edges and vertices
- **Mesh:** Points, edges and faces that make up a 3D model. Mesh can sometimes resemble a “wireframe” or “net” in the shape of the model
- **Model:** a completed 3D modeled object, or the act of building a 3D object in modeling software
- **Points:** interchangeable with vertices
- **Scene:** The building space in Blender. The scene is where you will create the object



- **Vertices:** the smallest components of 3D models, vertices are connected by edges (lines) to create faces. Singular vertex. Sometimes referred to as “points” in other forms of modeling.

### Keyboard Shortcuts

*Shortcuts with another shortcut nested under them indicate pressing in sequence*

- R – Rotate
  - o X – on the X axis
  - o Y – on the Y axis
  - o Z – on the Z axis
- # Pad: All the keys on the number pad have a shortcut purpose (useful are bolded)
  - o **1 – enter front view**
  - o 2 – rotate view up
  - o 3 – left side view
  - o 4 – rotate view left
  - o **5 – enter orthographic view (shows grid)**
  - o 6 – rotate view right
  - o 7 – top view
  - o 8 – rotate view down
  - o 9 – redraw screen
  - o 0 – camera view
- “Shift” + “A” – Add material to model
- “Shift” + Center mouse – shift perspective without disturbing scene
- “A” – select or deselect all material
- “B” – regional select
- “C” – Selection with brush/circle tool
- “E” – Extrude (only edit mode)
- “H” – Hide Selected
- “M” – Move selection to layer
- “N” – Opens *transform* menu
- “R” – rotate
- “S” – Scale
- “X” – Delete selection
- “Z” – Toggle faces (show mesh or faces)

### Method

#### **Stage 1: Creating the First Sketch**

Collect ceramic fragments to be measured and ensure to the best of your ability that they are all from the same vessel.

1. **If using the printable rim diameter guide linked above, ensure that the scale is correct before proceeding. Use a ruler and verify that each increment on the x and y axis represents 1 cm,**
  - this allows you to measure the radius of the circle you are estimating
2. Align ceramic with the corresponding curve
  - This can be challenging, especially with broken ceramics

- It is easiest to start with any rim fragments that may be present and work with the flat edge
- 3. Write down the radius information and attempt to sketch the profile with the values you generate
  - Some points on the profile will be challenging to measure, if that is the case it is possible to use a *very* soft modeling clay while the sherd is in a plastic bag and press the clay gently to the point you are trying to get a curve from.
  - Place the clay on the rim diameter guide and measure the curve

### Stage 2: Scanning the Ceramics (Optional)

*Scans of ceramics can be merged into a 3D model made of a pot. If this is a goal, follow the instructions below to access guides on cost effective methods to produce 3D models. 3D models can be made using a process called photogrammetry where photographs are compared using algorithms and stitched together to reliably represent the physical geometry of an object. This is the most cost-effective method for creating 3D models. Some programs that can be used to generate this data are listed below. Video tutorials for producing models are available for each.*

- <https://alicevision.org/#meshroom>
  - o Freely available models created using meshroom is a highly sophisticated program
- <https://www.agisoft.com/downloads/installer/>
  - o Starting at roughly \$179 USD, Agisoft Metashape is widely regarded as one of the most successful programs for creating 3D models of any scale.

### Stage 3.1: Building the First Rough Model (Profile)

1. Scan the sketch created in stage 1 and ensure that the shape of the pot sketched clear
  - Save the image in a place that is easy to find
  - It is usually best practice to create a working folder where you can save all files associated with the project.
  - Ex - C:\Documents\3D Modeling (an example of where you can save your folder)
  - **If you have a photo that is useful you can skip the drawing stage and scanning and use that instead**
2. Open Blender and clear your scene
  - Upon opening, the scene will have a block centered on the grid, select this block and tap the *delete* key on your keyboard
3. Import your image into Blender
  - Tap “Shift” + “A”
    - When your mouse is positioned in the scene this will open a new menu
  - Select “Empty” followed by “Image”
  - This creates an image layer for your reference picture
    - These layers appear in the scene tree on the right hand side
4. The properties panel on the right side features a small empty image logo

- Click on this empty image logo and browse your computer for your image (Figure 1)
  - See figure 2 for the panel you will need to use to import the image into the scene
5. When you have added your image, use the following sequence of keyboard shortcuts:
- RX90\*CLICK\* followed by tapping S and dragging the mouse.
- This will get your reference image in the right position for building over top of.
    - R – Rotate
    - X – on the X Axis
    - 90 – 90 Degrees
    - S – Scale (drag)

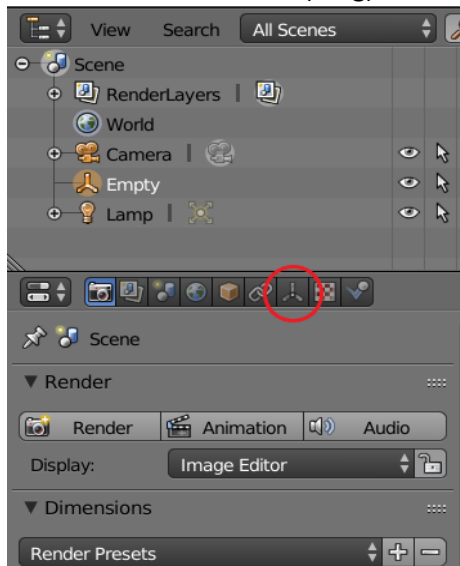


Figure 2 Empty Image Logo

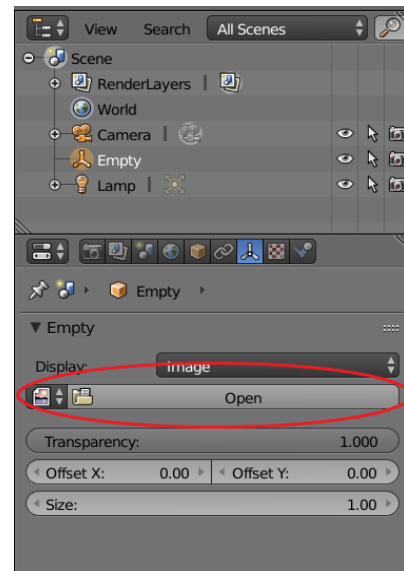


Figure 3 Import Image

6. Clicking on the position arrows will allow you to reposition the image (red and blue arrows). The center of the image should ideally be at the centre point of the grid. The image can also be moved one direction at a time by clicking and dragging the coloured arrows.
- X – red
  - Y – Green

- Z – Blue

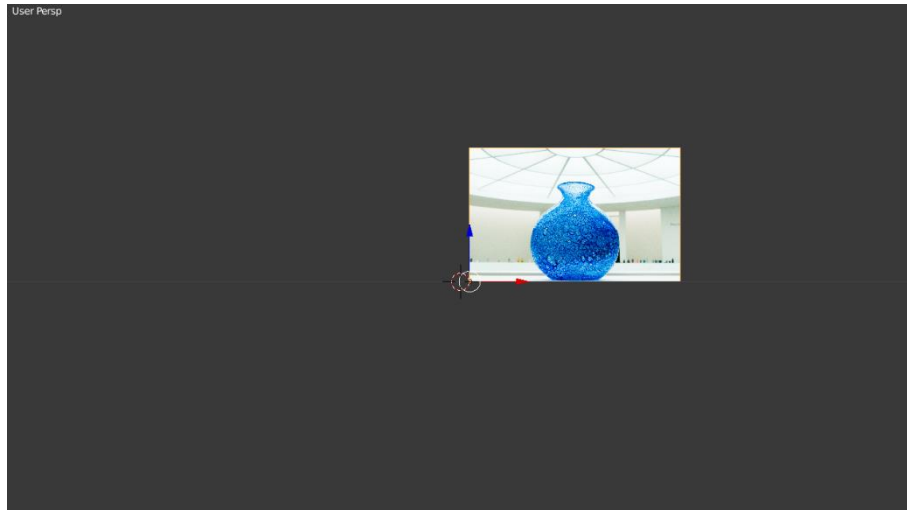


Figure 4 Center the image relative to the grid using the red (X axis) arrow

7. Tap **1**, followed by **5** on the number pad. This allows you to enter “Front Orthographic View” or FOV.
  - FOV displays a 3D object as a 2D object and this makes
  - This makes it much simpler to edit the entire 3D object
  - FOV can be returned to at any time by pressing 1 followed by 5 on the **number pad**

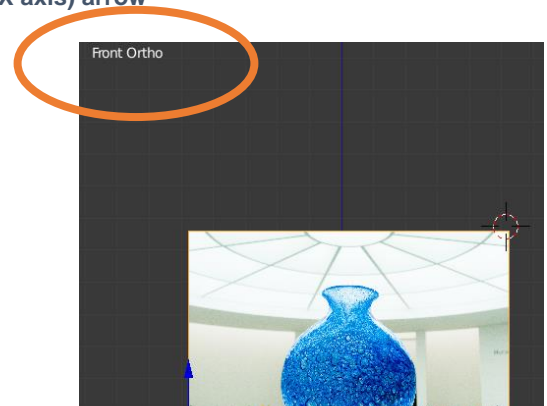
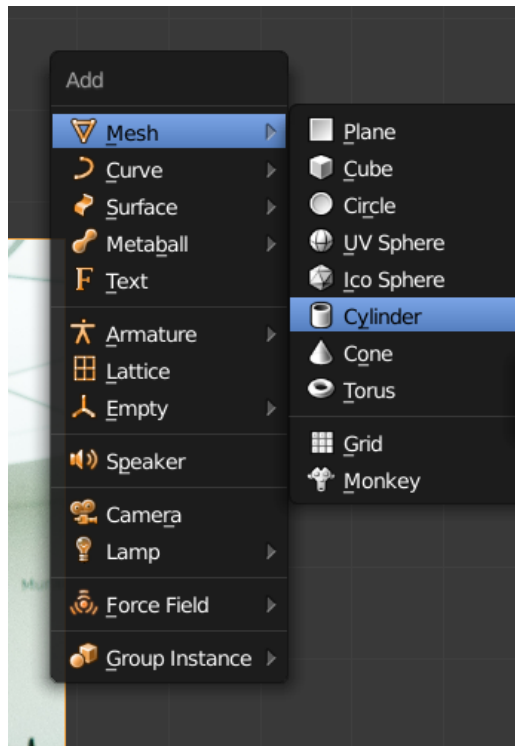


Figure 5 Verify you are in FOV by checking the top-left corner of the scene

8. Begin adding mesh by tapping Shift+A
  - Select “Mesh” followed by “Cylinder”
  - You can adjust the number of vertices (and as a result the number of faces and the smoothness of the model) on the model using the “Add Cylinder” menu that opens after the creation of the cylinder
    - The “Add Cylinder” menu opens in the bottom left corner
    - By increasing the number of vertices, you increase the smoothness of the model. For a first rough model you can likely get away with using 30. The model will look fairly blocky
    - Adjusting the radius changes the size of the base circle

- A small circle is ideal for a rounded bottom pot



9. Switch from "Object Mode" to "Edit Mode" on the bottom menu panel

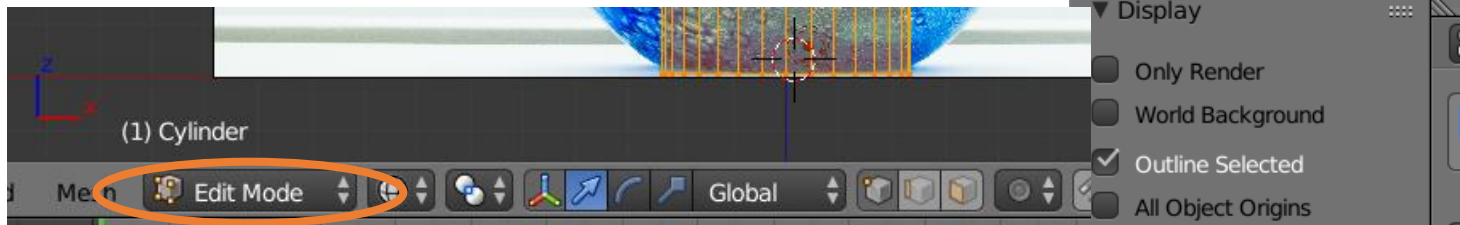


Figure 5 Switch to Edit mode

10. Tap "N" to open the *Transform* menu
  - Scroll down to the "View" menu on the transform panel and adjust the clip settings
    - The "Start" value should be no greater than 0.1 to ensure you can always see the object you are sculpting
    - The "End" value should be no lower than 1000 to ensure the object does not disappear when zooming out

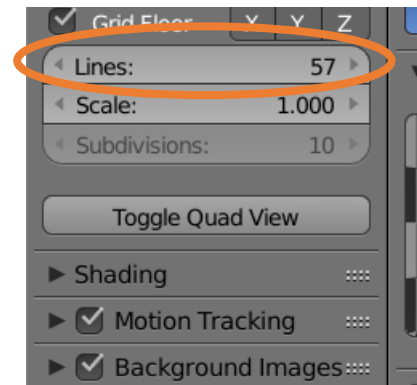


Figure 6 Adjust the number of lines

11. Ensure that you are working in metric units as opposed to "Blender Units" or Imperial
  - Ensure you are in "Edit Mode"

- Toggle to the “Type of Data to Display and Edit” Tab
- Under this menu toggle *units* to “Centimeters” and *length* to “Metric”
- You should notice the “Dimensions” panel of the “Transform” menu change from points to cm
- The grid should now be visible. When zoomed in to the cm level, the grid points can be counted to measure while sculpting.
- Under the “Display” menu, adjust the number of “lines” that the grid has
  - The ideal number of grid lines will be more than the largest value measured on the Rim Diameter Chart

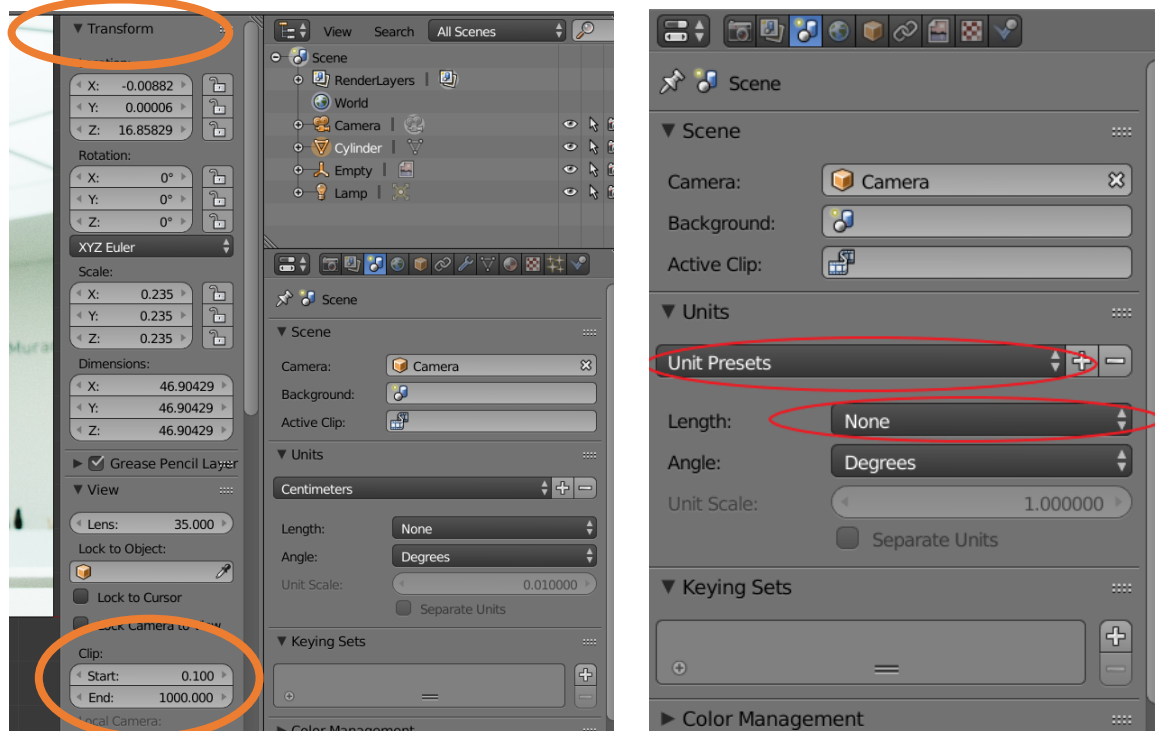


Figure 6 The “Transform” and “Type of Data to Display and Edit” Menus

12. Align the cylinder with the bottom of the picture and scale it down (“S” and drag) to the desired size of the first “band”

- The modeling process is like stacking coins, each band will build on the last

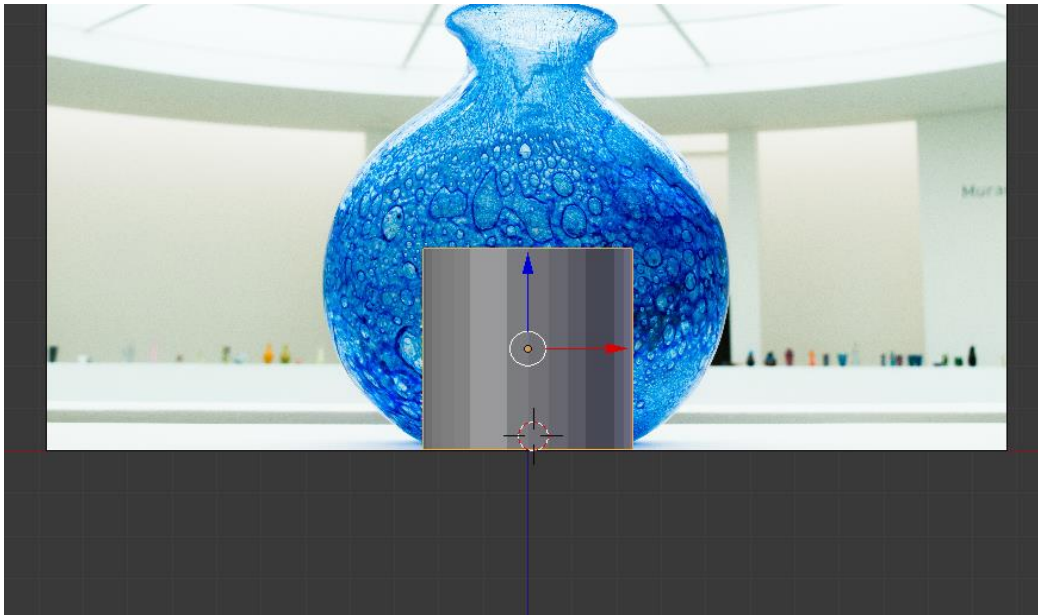


Figure 7 Align cylinder with base of image

13. Tap “TAB” followed by “Z” making sure the cylinder has an orange outline. This turns on edit mode

- In Edit Mode your cylinder will have a wire-mesh appearance
- Ensure that the first cylinder is scaled down to the size you would like your bottom “coin” or cylinder to be (in terms of the radius of the base of the cylinder)



Figure 8 Scale down the cylinder and ensure you are in edit mode

14. Tap "A" to deselect all the points
15. Tap "B" To use the selection tool and drag the box over only the points at the top of the cylinder.
  - These points can now be manipulated as a group

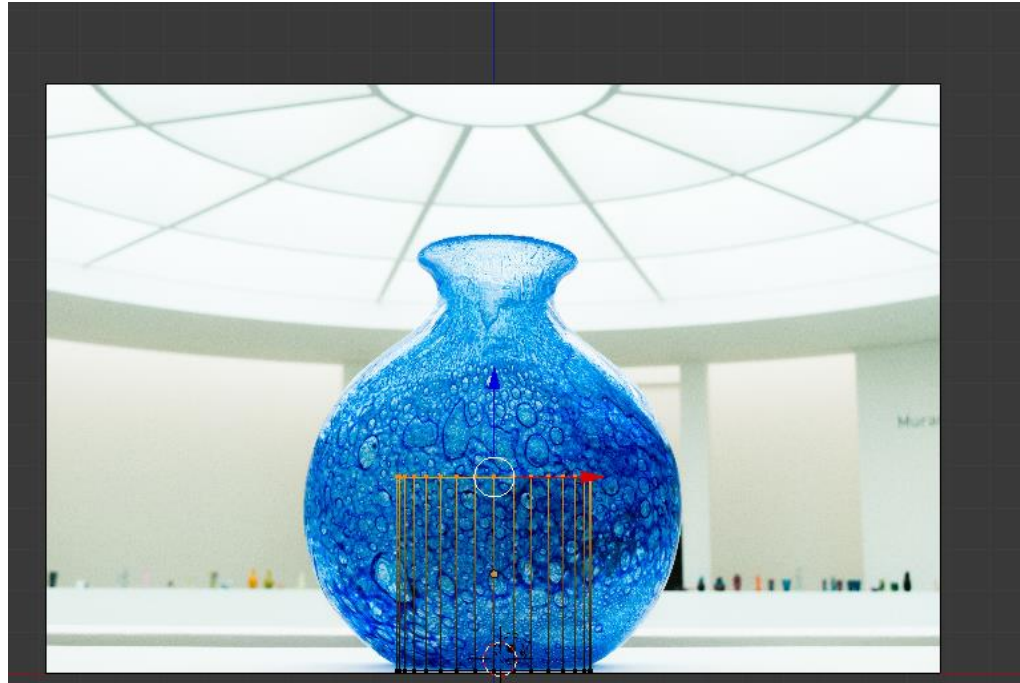


Figure 9 Select only the top layer of points

16. You will have the option to use the blue arrow to slide the points down, doing so will adjust the thickness of the first band
17. Tap "S" and drag away from the points to scale the top layer of points in this band up to the new desired thickness.
18. Tap "E" and click
  - This creates a new layer of points that can be manipulated as a group
19. Select the blue arrow and drag up
  - The next band should be extruded in a straight line up
  - Drag up to the desired height
  - **Pro Tip:** To ensure that the model is as smooth as possible ensure that the bands are not spaced far apart. The closer together each band is, the smoother the model will appear. Should the model be 3D printed in the future, a greater quantity of smoother bands (as opposed to a smaller number of thicker bands) makes for a more natural feeling print.
    - If you are making a test or preliminary model this is not important. This should only be considered for more polished final models



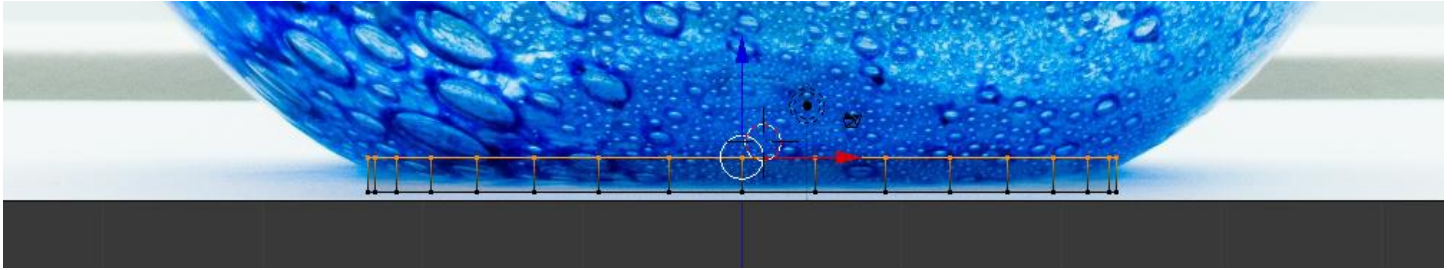


Figure 10 Click and drag the Z (blue) arrow

20. Tap “S” and again, scale to the desired thickness.

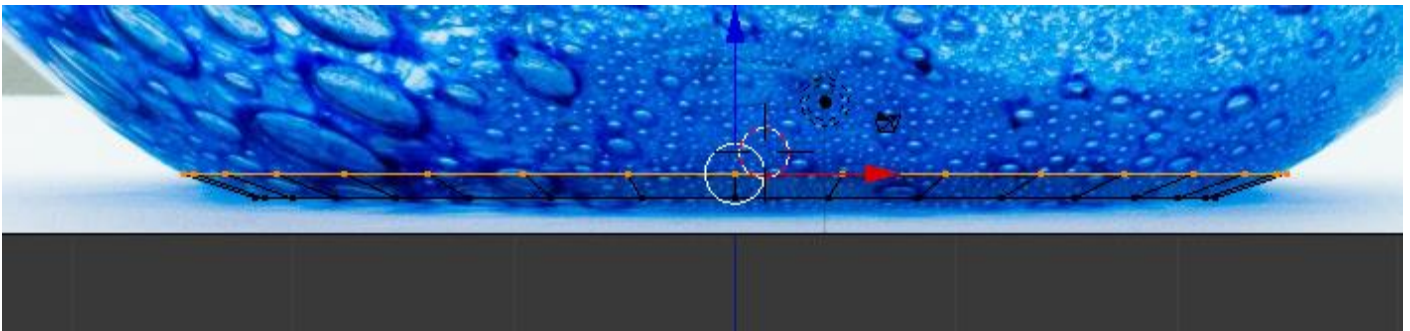


Figure 11 Scaling points as a group causes them to fan out. Align them with the image as if you are tracing it.

- Click to set the band in place

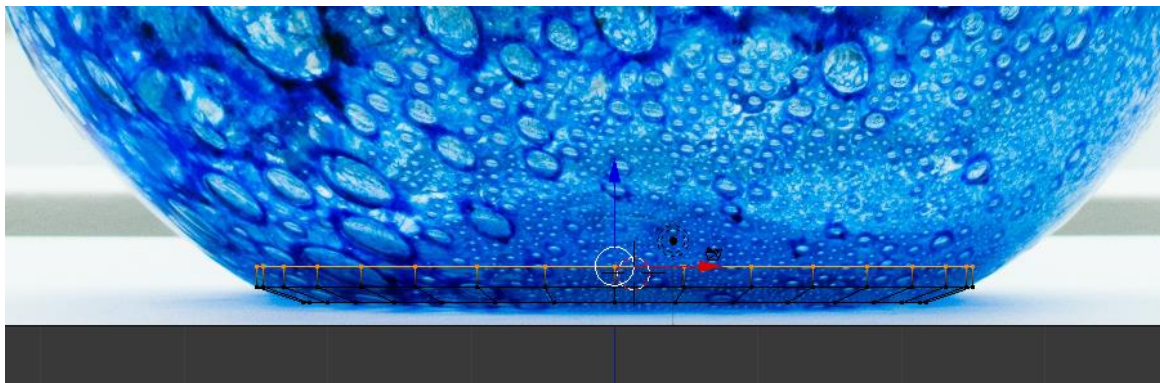


Figure 12 Extrude a new band and raise it to the desired level

21. Repeat steps 18, 19 and 20 (in that order) until the outer profile of the pot has been constructed

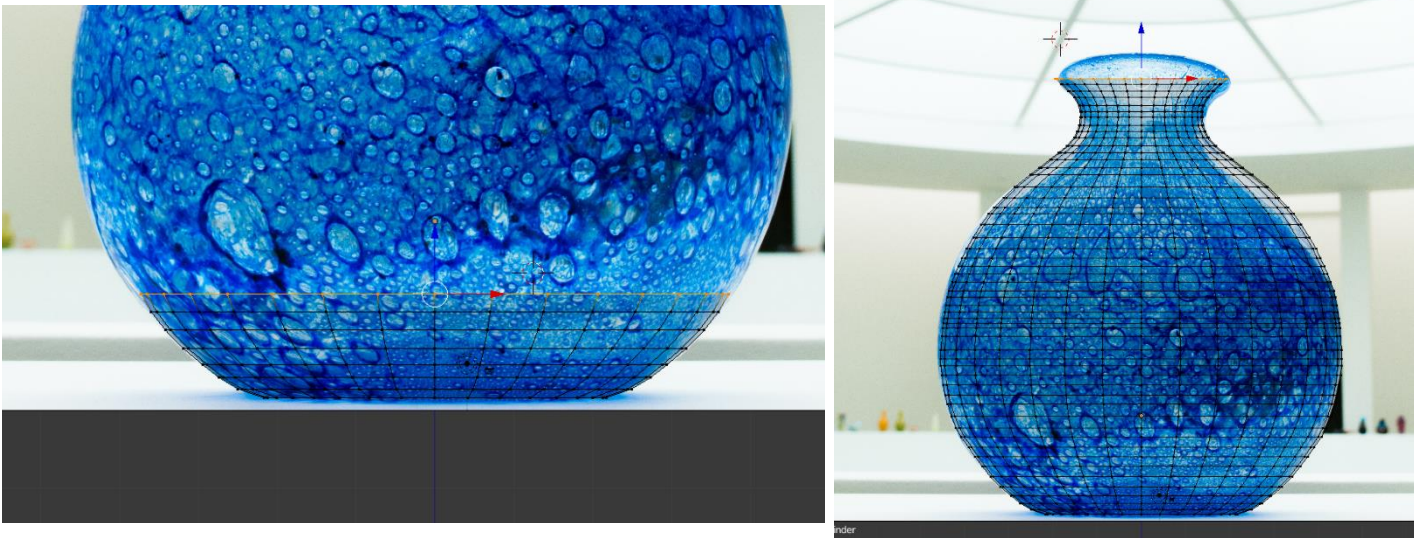


Figure 13 Continue extruding new bands and resizing them to match the image

### Stage 3.2: Building the First Rough Model (Internal Dimensions)

1. Tap “7” on your number pad
  - This will take you to “Top Orthographic View”

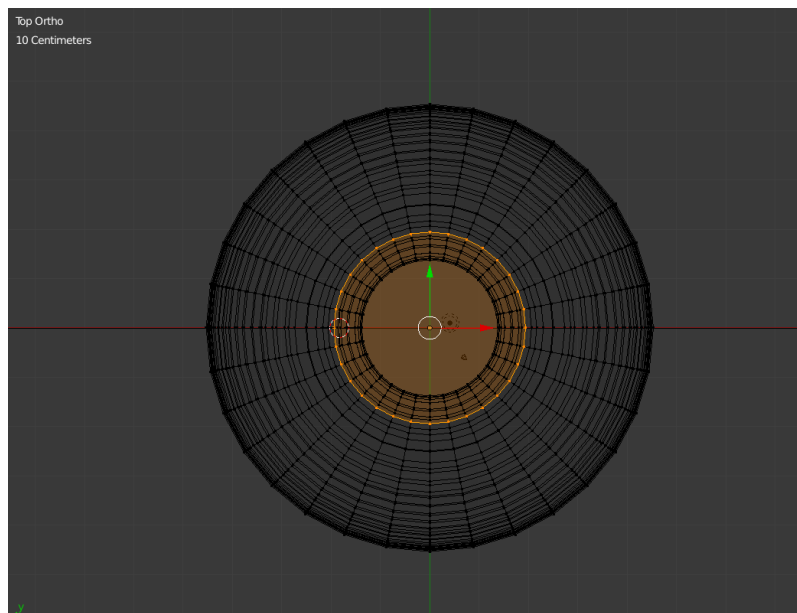


Figure 14 Viewing the sculpted pot from the top allows you to gauge and measure the thickness of the rim

2. Tap “E” to extrude as usual and click to set it in place. This creates a second workable circle in the exact same position as the previous band

- Tap “S” and drag the mouse towards the pot you are building
  - This scales down the circle at the same level as the top of the rim
  - This new circle should be scaled down to the thickness of the rim
3. Zoom in and switch back from “top view” to “orthographic view” by tapping “5” on the number pad
- Zooming in the units in the top left corner of the Scene should change depending on how closely zoomed you are (m, 10cm, cm, mm)
    - Zooming in further the grid should become further sub-divided and shift from cm to mm
    - Working in mm is usually the most useful when sculpting the internal dimensions of the pot
4. Extrude a new layer as before
- Tap “E”
  - **This time, drag the new layer down**

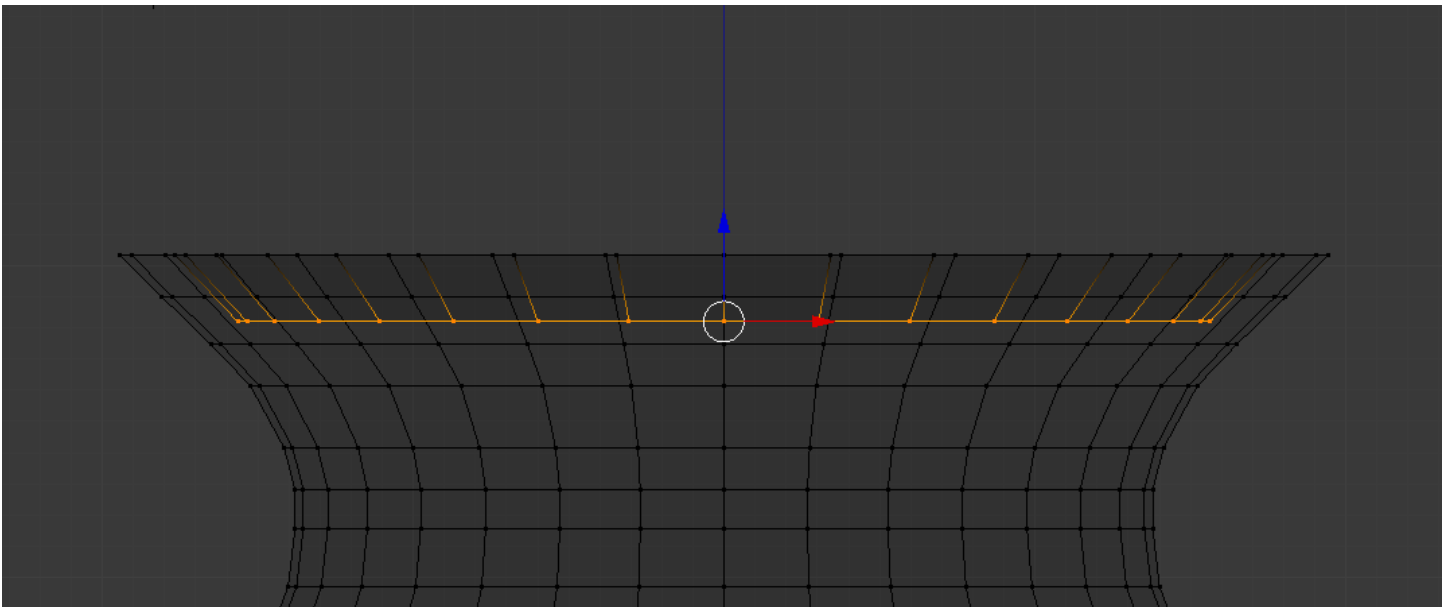
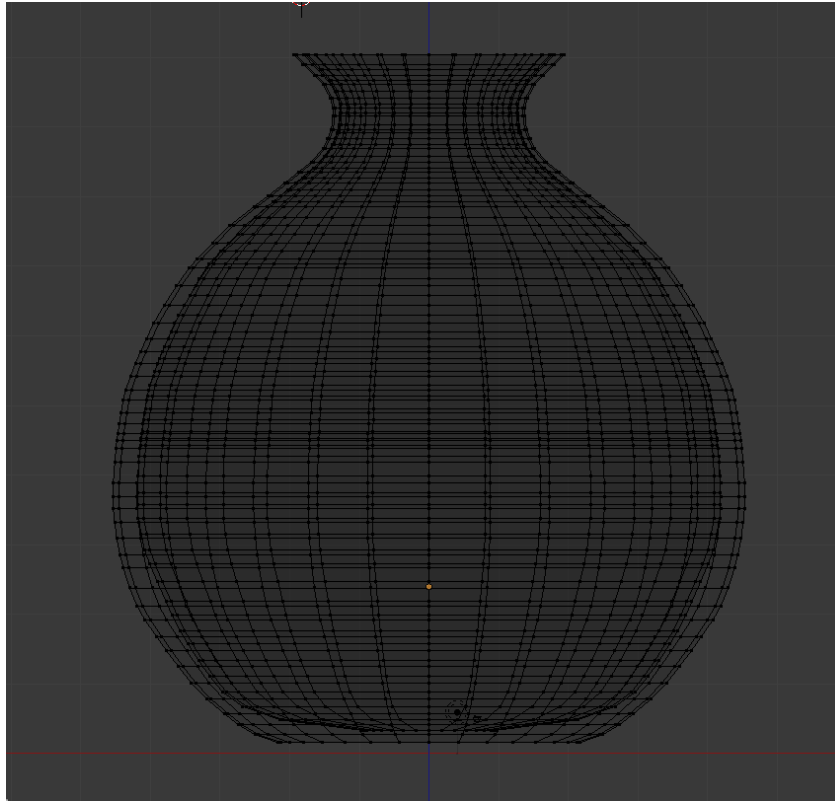


Figure 15 while extruding down you are sculpting the internal dimensions of the pot

5. Using the scale feature (S), resize this band to the desired thickness of the pot’s rim
- **PRO TIP:** do NOT set the bands created for the internal dimensions at the same level as the bands created for the external dimensions as this will limit your ability to adjust and fine-tune
    - **Note here the orange band is staggered away from the other edges**
6. Repeat the process following the same method as steps 17-19 in stage 3.1
- This will be slightly different as while scaling down you will need to measure the internal dimensions
    - Count the number of mm between the two bands as you are scaling them

#### Stage 4: Fine Tuning

1. Zoom out to view the entire sculpted pot
  - Some of the bands may appear to not be thin/thick enough
  - These will need to be adjusted



*Figure 16 A final wire mesh model of the glass vase. Note the walls of the vessel. The internal dimensions of the vessel appear a darker grey and the walls appear a light grey.*

2. Using the “B” Selection tool click and drag across the band you want to adjust
  - If internal and external bands have been staggered appropriately you should be able to drag across the pot and select only one layer of points.
3. Tap “A” to deselect all points once they have been resized properly
4. Repeat this process until the model looks smooth
5. Scale the bands as needed to ensure the model is as smooth as possible

#### Stage 5: Merging Models

*Scanned models can be merged into the model. This process can be imagined to be similar to matching puzzle pieces to the picture on the box. For this stage of the method a “Heart shaped” pot from the Providence Bay archaeological site will be used*

1. Ensure that the model you have created has been saved
  - "Export" the model and save a project file
    - To export go to *File>Export>.obj*
      - .obj files are one of the most common 3D models and are compatible with many programs and 3D printers
    - To save a project file go to *File>Save As*
      - Save the project to your working folder
  - Open the file menu and export the model to your working folder, giving it a unique name
  - Save the scene as a Blender file to your working folder, **this prevents data loss**
2. When merging scanned ceramics it is usually best to work in object mode. Ensure that the model's faces are visible by tapping "A" to select all points (The wire mesh model will turn

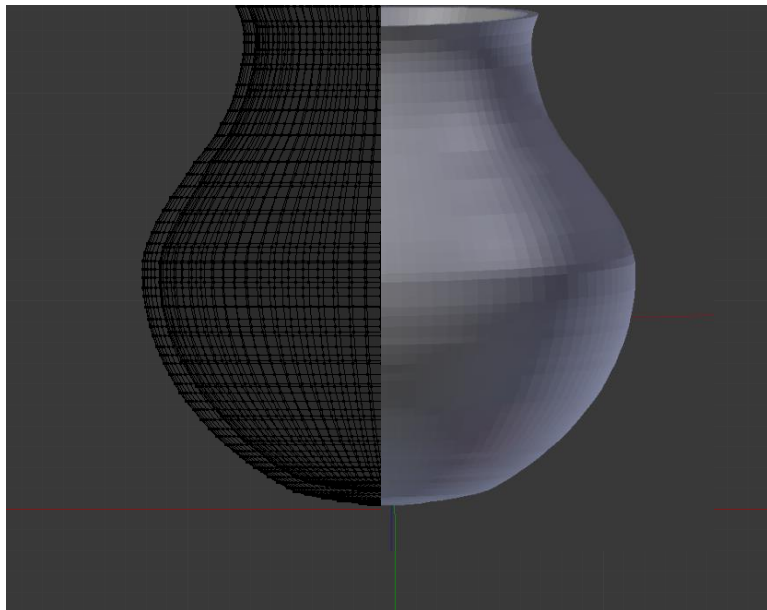


Figure 18 Left: Wire mesh model in "Edit Mode" Right: Solid model in "Object Mode"

orange) followed by "Z"

3. Import the scanned models into the scene
  - 
  - You will need to verify the scale of the models you are working with and ensure that the models are scaled down appropriately. This process differs depending on the method used to create the scanned models.
  - Many scanners treat the units they capture data in as millimetres, but when imported into blender, each millimeter can be treated as a centimeter
  - Ensure you have the correct model selected in the scene tree (farthest right-hand side menu) See Figure 19

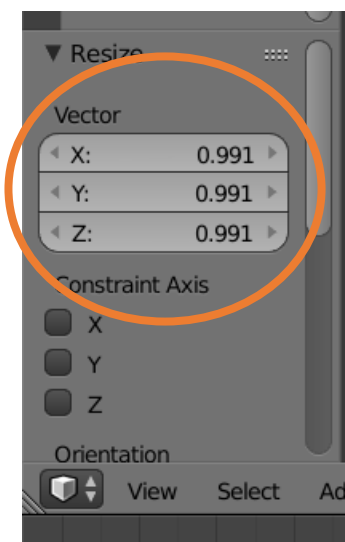


Figure 19 Ensure X, Y and Z scale are scaled uniformly



- Tap “S” to scale up or down the model. Dragging to scale slightly and clicking will open the “Scale” menu in the bottom left hand corner
  - Here you can adjust the scale on the x, y and z axis uniformly by setting the values
  
- 4. In order to better see what you are doing while manipulating the models it is best to change the colour of the model so there is a visible difference between the model and the scanned ceramics
  - Open the “Material” menu on the furthest right side below the scene tree
  - Select “New”
  - In the new menu select the first white box, this will open a colour selection menu
  - Select a new colour and close the menu
  - See figures 20 & 21
  
- 5. Import scanned models into the scene
  - File>Import>(select the relevant file extension)
  - Browse for the model you would like to import
  - The model should appear in the scene tree and scene after being imported

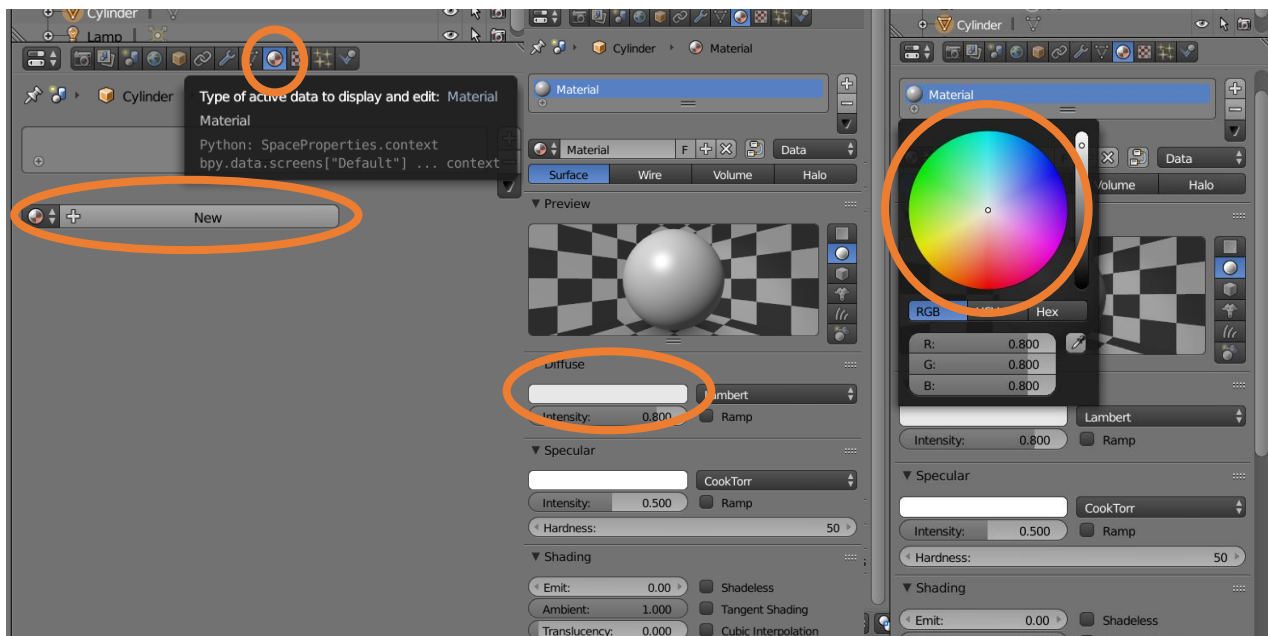


Figure 20 Select new, select the material colour box, choose a new colour

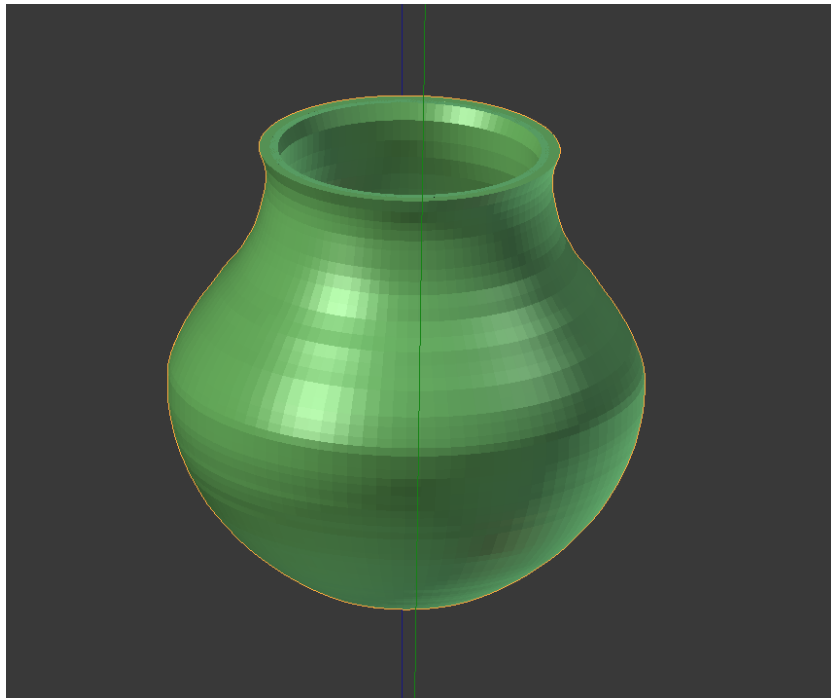


Figure 21 Model with altered texture (colour)

- In order to make your workspace tidy, rename the model in the scene tree by right clicking it and giving it a name that will make sense while working

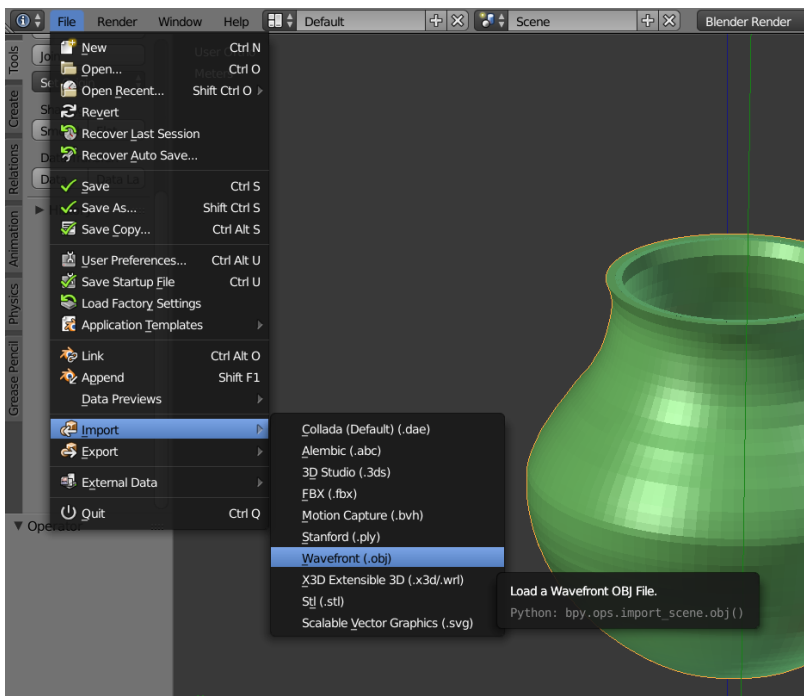


Figure 22 Import relevant files

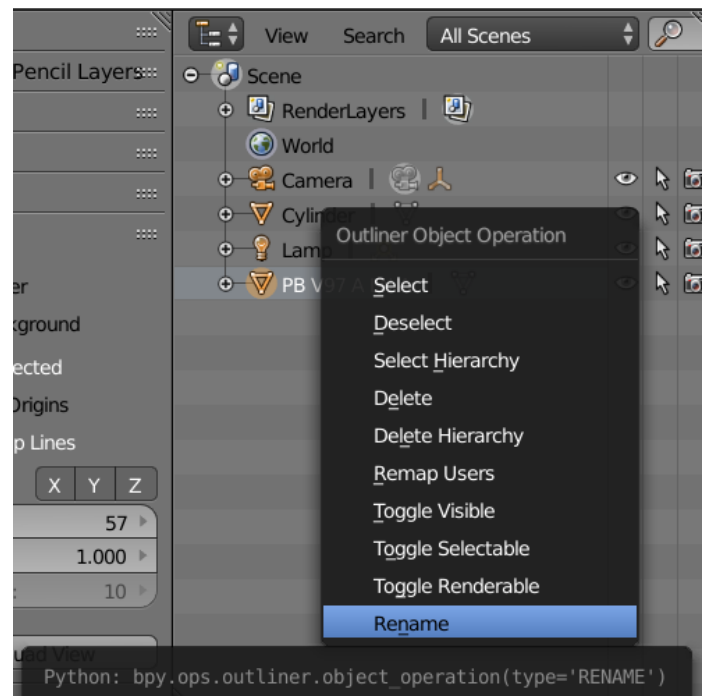


Figure 23 Rename model in the scene tree to reduce confusion

- Imported models will often need to be scaled up or down depending on the scanner settings

- Blender may interpret the units used for scanning as the standard unit set in Blender (cm)
  - As a result, scaling the model a uniform amount on the x, y and z axis will result in a uniform and appropriately sized model
- Tap “S” and drag away or towards the model, click after dragging to set in place
  - Away – scales up
  - Toward – scales down
- In this case the imported scan needed to be scaled down by factor of 100 to represent the real-world dimensions

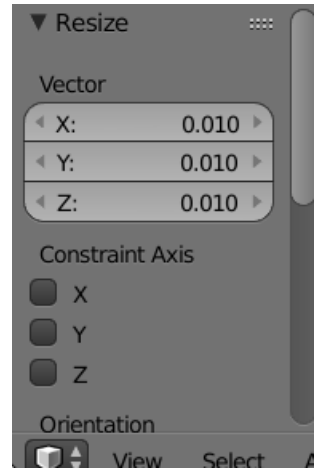


Figure 24 Ensure the X, Y and Z axis are uniformly scaled by 10, 100, 1000 etc

#### 7. Adjust position of model using the coloured arrows

- Repositioning the scanned files on the model takes time and multiple revisions so this process can take a while. It usually works best when done in one sitting so ensuring you have enough time to dedicate to this can be helpful
  - Red – X axis
  - Green – Y axis
  - Blue – Z axis
- The scanned model will need to be moved close to the constructed model

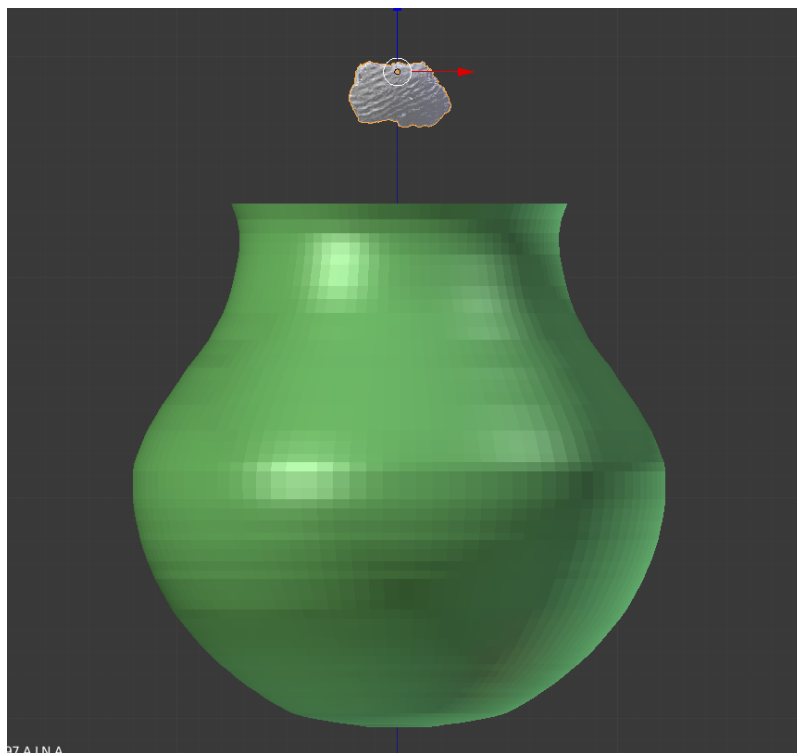


Figure 25 Reposition scanned model using the X, Y and Z arrows



8. Rotate the model using the “R” command
  - Repeat the process until the scanned model is correctly aligned with the new model
  - This process may result in models not fitting in the expected way, this can indicate two things
    - The original pot was not balanced or perfectly round at all points
    - The model needs to be revised
  - The direction of rotation can be altered by tapping R followed by X, Y and Z
    - These commands control the direction of the rotation
    - Often multiple commands will need to be used in order to rotate the model correctly

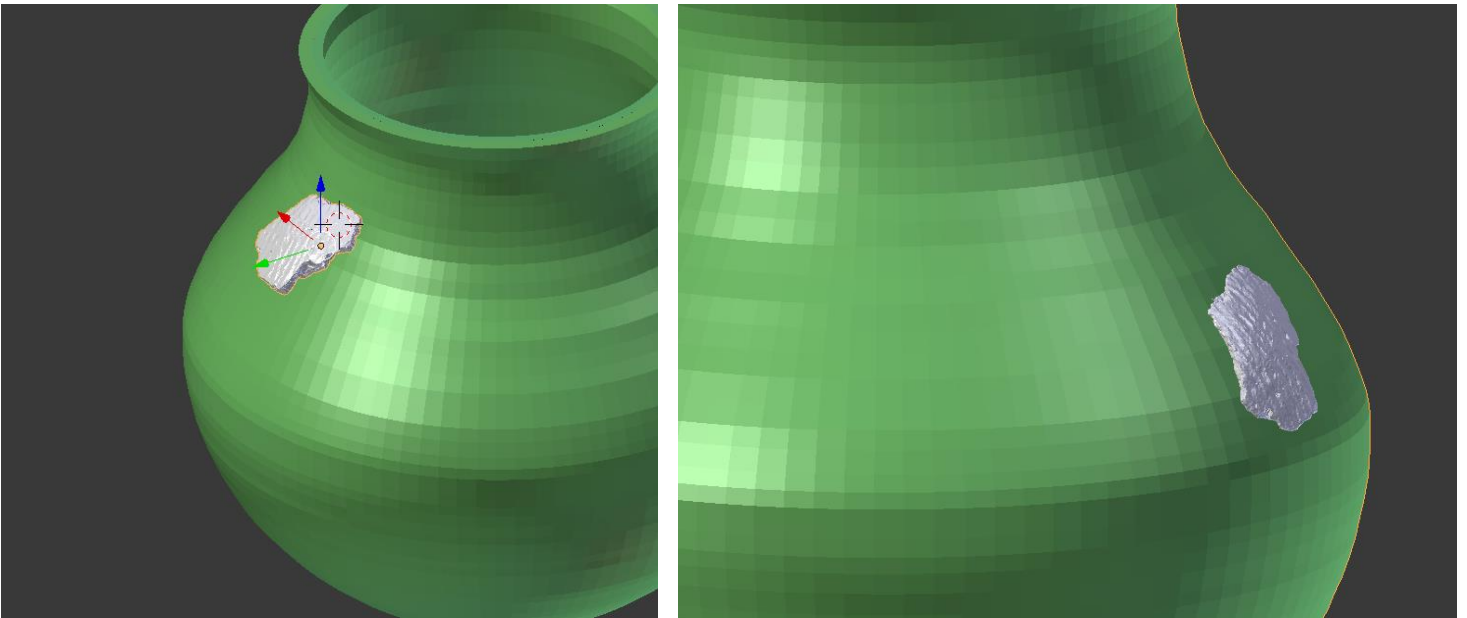


Figure 26 Continue to rotate the scanned model until it can be merged with the constructed model

9. Revisions
  - As more scanned models are added to the scene revisions will likely need to be made.
    - Repeat steps 7 & 8 to ensure that the scanned models align as uniformly as possible

### Stage 6: Preparing for Export

*In order to finalize and export the model you have built, all merged objects need to be joined to the new model.*

**Warning: Once models are joined there are no changes that can be made to each individual model.**

1. Right click on a scanned model while holding “Shift”

2. Continue to hold “Shift” while right clicking scanned models

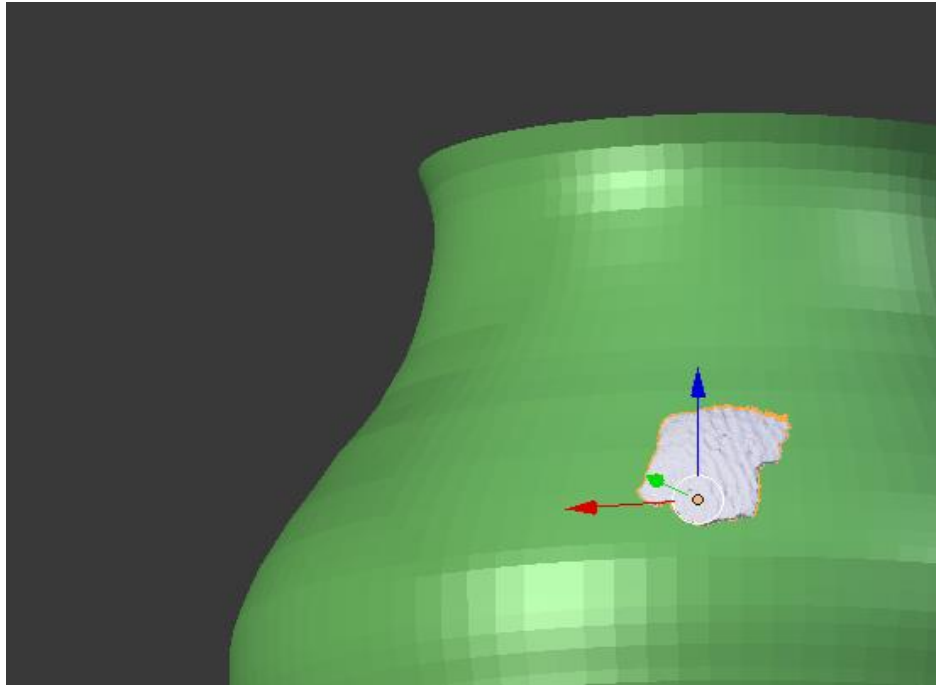


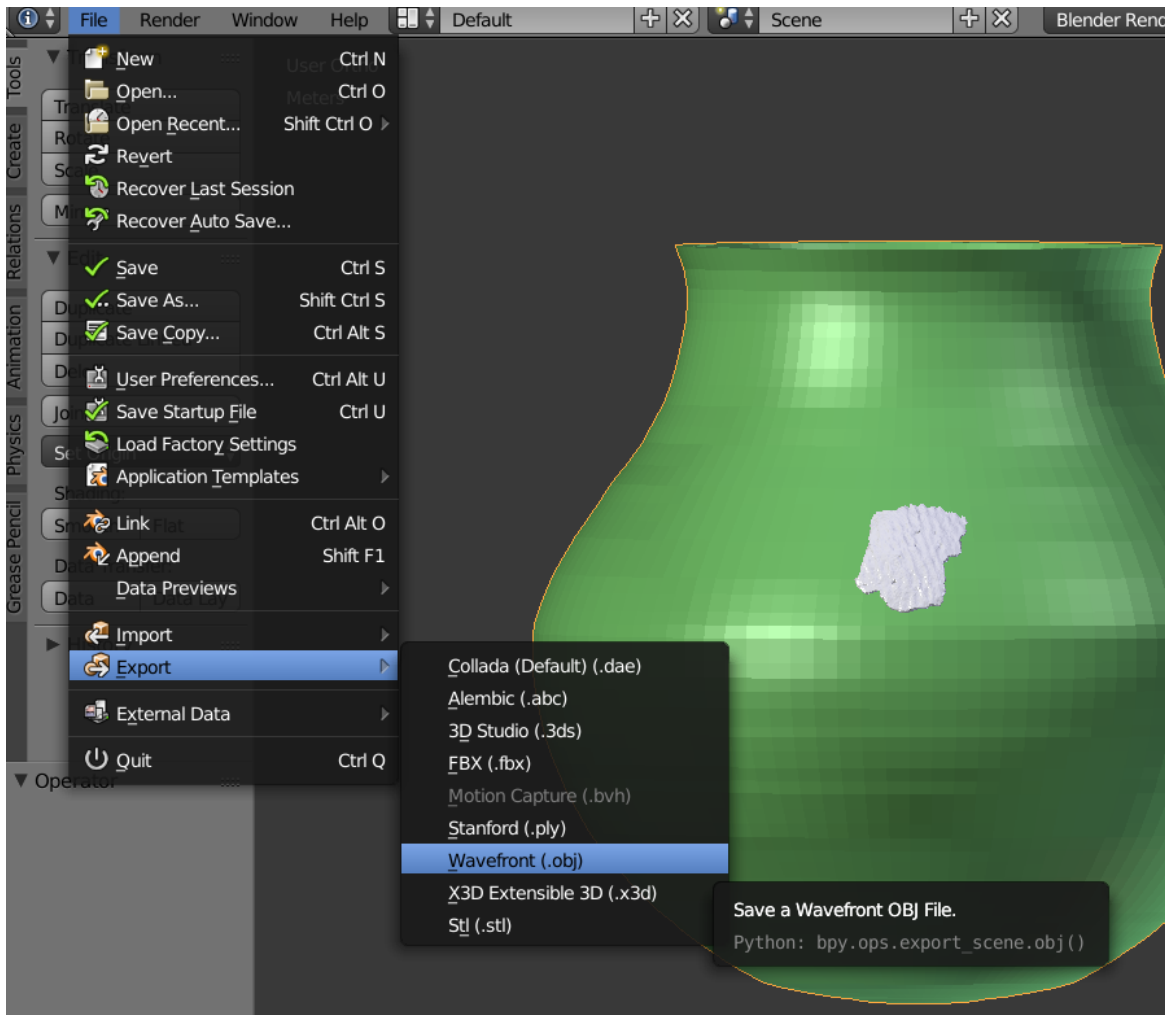
Figure 27 Right click while holding “Shift” to select the scanned ceramic. Continue to right click on scans while holding shift

3. Click the constructed model last, this makes it the “Parent Object”
  - The parent object is the model that all other models will be joined with. It will also be the only model that remains in the scene tree when all models are joined
4. Press “Ctrl + J” to join objects
  - If this is done correctly the scene tree should now show only the parent model, lighting and empty image. If there are still stray models that have not been joined right click them and then the parent model
  - This can also be done in stages
    - Select a model by right clicking and holding “Shift”
    - Right click the constructed model (this will become your parent model) and tap “Ctrl + J” to join, repeat until all are joined
5. When all models are joined export the final model to your working folder
  - If you plan on 3D printing the model created the best file formats to export in are .ply, .obj and. stl



Figure 28 Scene tree post joining models.

➤ Be advised .stl files cannot be printed in colour



6. Double check that files have save correctly

- You can open them in a 3D model viewer such as paint 3D, which comes with windows 10 computers or Meshlab, a free 3D model view/edit program

➤ <http://www.meshlab.net/>

## Curriculum Vitae

**Name:** Hillary Kiazzyk

**Post-secondary Education and Degrees:** University of Western Ontario  
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2013-2017 B.A. Honours Anthropology

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2017-2020 MES Collaborative Degree

**Honours and Awards:** Western Graduate Research Scholarship  
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Scholarship  
2019

**Related Work Experience** Research Assistant  
The University of Western Ontario  
2017

Teaching Assistant  
The University of Western Ontario  
2018, 2019

### **Publications and Conference Presentations:**

Kiazzyk, Hillary V. (2017). Archaeology, Accessibility, and 3D Imaging

Kiazzyk, Hillary V. (2019). Visualizing Anishinaabe Ceramics. Annual WAGS Conference

Kiazzyk, Hillary V. (2019). The Providence Bay Site. MISHI Annual Meeting

Kiazzyk, Hillary V. (2020). 3D Printing Fragmentary Ceramics. MISHI Annual Meeting\*  
Cancelled due to Covid 19